POWER

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"Sol" Engineer's Advice

MY son, consider the small steam leaks, how they grow. They cease not, neither do they sleep. They hiss and spue out in derision at thy fondest dream of great things to be accomplished, verily, even while thou art boastfully declaring thy great worth to thy employer—which would be even greater if thou only hadst a chance.

Consider, also, the invisible leaks, perchance, through the brickwork of the furnace. Surely thou knowest they also are wasteful. Say not, "the Old Man will not supply material and help." Help thou thyself to some good yellow clay if nothing better be at hand; are not bricks also made of the same?

Consider again thy raiment, which may become thin; even more so in that part which cometh in contact with thine easy chair, lest it afford thee scant protection should thine employer rise up in just indignation at thy slothful ways and apply his boot vigorously.

If thou knowest not all that which is taught in the books, thou doest well if thou doest thoroughly all those things which thou dost know.

Surely, thy employer can see. If not, it is clear then why thou art still on his payroll! My son, get thou busy.

Steam-Electric Power Plant at Hauto, Penn.--I

By Warren O. Rogers

SYNOPSIS—The plant is located in the anthracite mining district to utilize coal dust and other unmarketable low-grade fuel in the boiler furnaces. At present there are eight 1000-hp. water-tube boilers and three 12,500-kw., maximum rating, horizontal turbines served by Leblanc condensers hung from the base of the turbines to take care of contraction and expansion. Condensing water is taken from the Hauto reservoir and, after passing through the condensers, is discharged into the reservoir 2800 ft. from the intake.

A boiler and turbine plant which eventually will have at least 32,000 boiler horsepower in 32 units and 100,000-kw. turbine capacity, exclusive of 25,000 kw. reserve, has recently been placed in operation at Hauto, Penn., by the Lehigh Navigation Electric Co. So far, however, eight 1000-hp. boilers are in place, although eight more of equal capacity may be added in the near future.

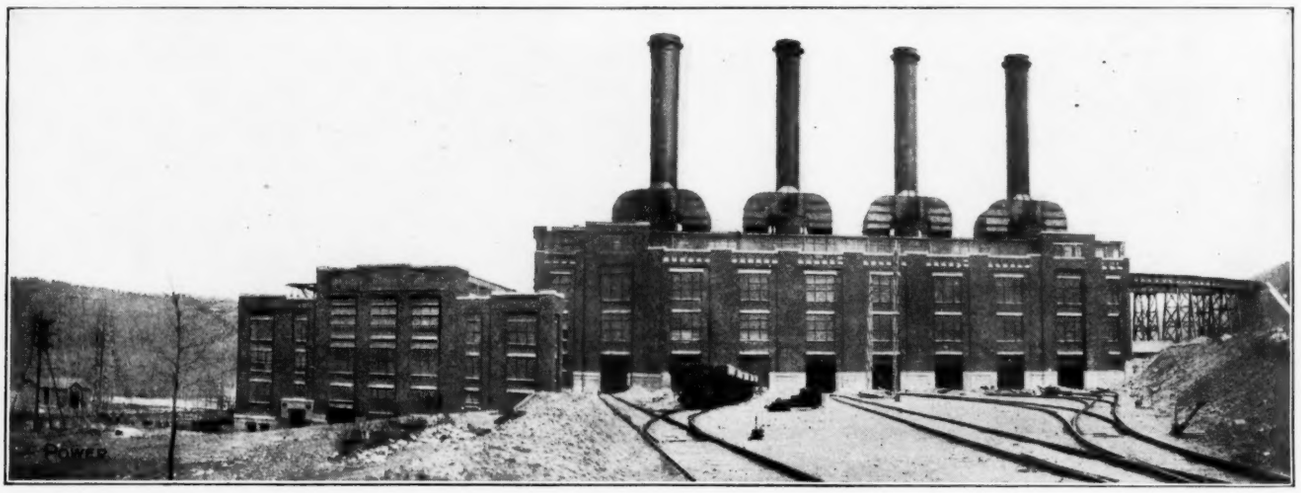


Fig. 1. General View of the Hauto Power Plant, Hauto, Penn., Containing at Present Eight 1000-Hp. Water-Tube Boilers and Three 12,000-Kw. Steam Turbines

Throughout the anthracite coal regions of Pennsylvania there are vast deposits of culm, washery screenings and the like, and, although much of this fuel is of fair calorific value it has but little, if any, market value. This refuse contains fine sizes of anthracite, such as buckwheat No. 3 and smaller, which can be burned in boiler furnaces properly designed and handled. It is proposed to burn this refuse near its place of production, thereby saving the transportation charges and transmit the electric power generated to near-by and distant points. One great electrical plant will supply power to surrounding industries in place of transporting coal to be consumed in many more or less uneconomical steam plants.

Building

To obtain an adequate supply of condensing water, the plant, a general view of which is shown in Fig. 1, is located on Nesquehoning Creek. A siding is provided from the Nesquehoning R.R., which connects with the Lehigh & New England and the Central R.R. of New Jersey. Construction was begun about 19 months ago, and the engineering and supervision work was done by the firm of L. B. Stillwell, consulting engineers, New York City.

The power house was built on a hillside. It is practically five stories high from the condenser basement to the coal-discharging room above the coal bunkers, the tops of which are level with the boiler-room roof.

The building is of heavy structural steel and brick, the face work being laid in texture brick. The sills, lintels, copings and base of the structure are of reinforced concrete, finished smooth. An unusual amount of window area has been provided in rolled-steel sashes with wire-glass panes.

The smoke uptakes are above the boiler-house roof, and the shape of each, Fig. 1, is due to the provision made for putting economizers on the roof at some future date, if desirable.

The overall dimensions of the present plant are 416x 195 ft. The building has two main sections in the form of a tee. The boiler room is 68 ft. wide and 285 ft. long, and is built at right angles to the turbine room, which is 131 ft. wide and 195 ft. long.

Turbo-Generators

There are now three 10-stage, turbo-generators, each with a maximum rating of 12,500 kw. The turbine blading is a modification of the Rateau form.

The generators, Fig. 2, are three-phase, 25-cycle machines, operated at 11,000 volts. The rotors have fan blades to draw air for cooling through the machine and discharge it at the top of the casing. This cooling air is taken from outside through air ducts into the conduit room, thence through cloth screens to an air chamber under the turbine casing. At 10,000 kw. the temperature of the generators does not exceed 40 deg. C. in a 24-hr. run.

In each chamber are three 208-kv.-a. reactance coils which are cooled by the air going to the generator. These coils consist of a continuous cable wound on a concrete core separated by wooden spacing stops with asbestos-pad

insulators between the cable and the wooden stops. A reactance coil is connected to each of the three leads of each alternator. Each reactance produces a 4 per cent. drop with 525 amp. flowing per terminal of each machine at 11,000 kw. and 100 per cent. power factor.

The main generating units are placed crosswise of the turbine room, and the steam pipe to each above the strainer extends in a long-radius bend to the header chamber. Each turbine has a 14x14-in. trip and throttle valve. The 14-in. elbow between the throttle valve and the strainer has a blind flange connection to which a U-bend pipe is bolted and acts as a support to the main steam pipe. Between the legs of the U-bend is a gage

Each main turbine exhausts into a No. 24 Leblanc condenser, Fig. 3, the largest of its kind yet built. The condenser is bolted to the underside of the turbine and hangs free, with about two inches between the bottom of the condenser and the basement floor. This gives the condenser free movement to expand and contract.

The double-impeller, centrifugal circulating-water pump is housed in the exhaust casing of the condenser; the small dry-air pump is on the outside, as shown. These pumps are mounted on the same shaft and driven by a single-stage, 445-hp. turbine, operating at 700 r.p.m. The shaft connection between the condenser and the turbine is long enough to allow for whatever movement of the

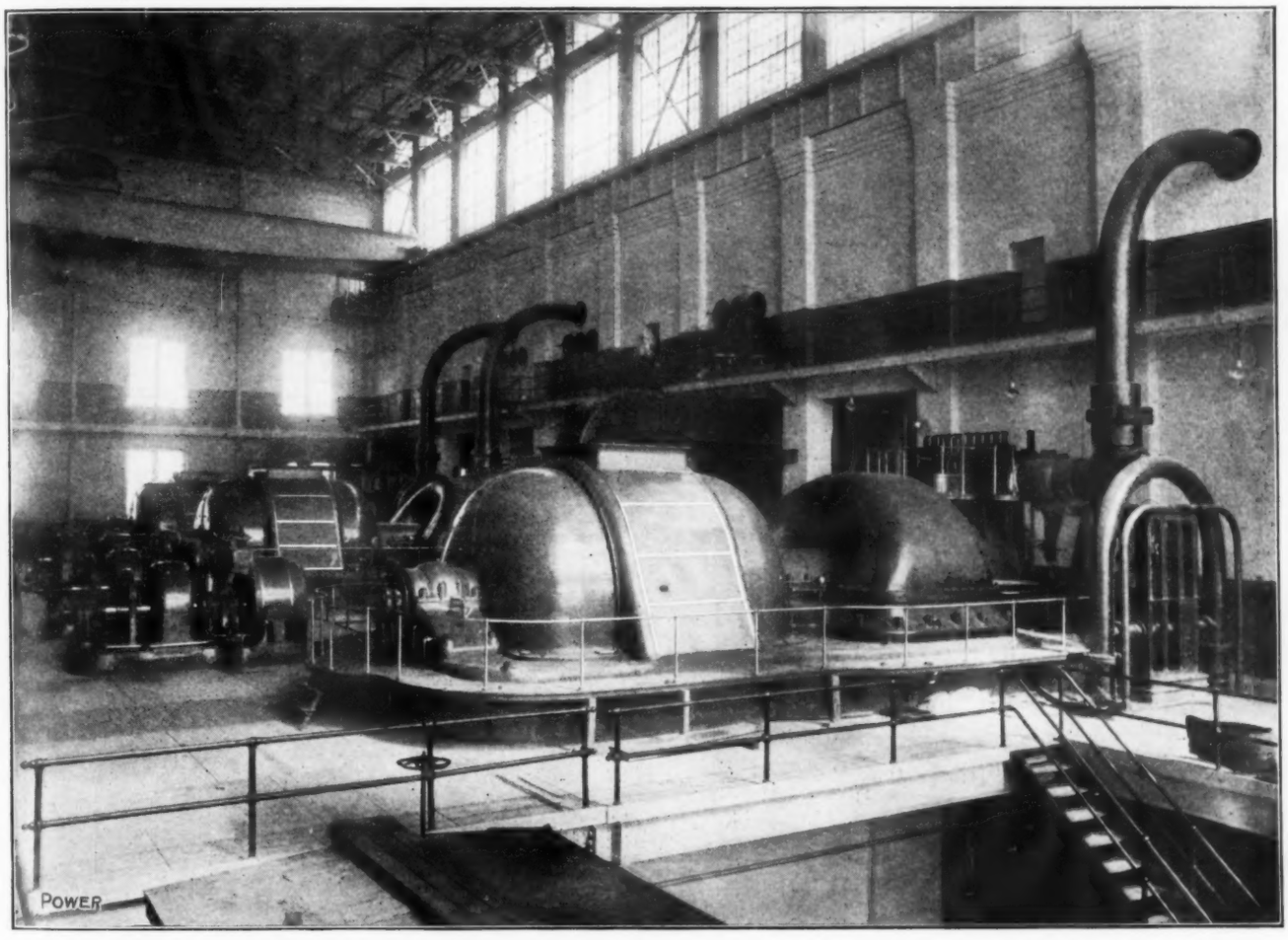


FIG. 2. THREE 12,500-KW. TURBINE UNITS; MAXIMUM RATING, 12,500 KW. UNDER NORMAL OPERATING CONDITIONS THE STEAM CONSUMPTION IS 12.3 LB.

board carrying the several gages, mercury column and signal panel for stopping and starting the unit.

The operating platform of the turbo-unit is about two feet above the concrete flooring. Between the first and second unit and between the third turbine and the end wall is an opening above the pump compartment in the basement.

Steel spiral stairways lead to the balcony and the basement from the operating floor.

Midway of the turbine-room floor at the generator end of the main units are three 300-kw., 250-volt exciter sets, two of which are direct driven by six-stage turbines, at 1800 r.p.m.; the other is driven by a 450-hp. induction motor at 750 r.p.m.

condenser takes place as a consequence of the changes of temperature.

Priming water, supplied by a set of reciprocating pumps, flows to the air pump until sufficient vacuum has been formed to lift water from the intake tunnel by atmospheric pressure. With a 29.1-in. barometer the condenser will maintain a vacuum of 28.1 in. when condensing 150,000 lb. of steam per hour.

CONDENSING WATER SUPPLY

Enough condensing water, not only for the present but when the total output of the station will be at least 100,000 kw., was necessary. It was, therefore, decided to construct a dam for the enlargement of the existing

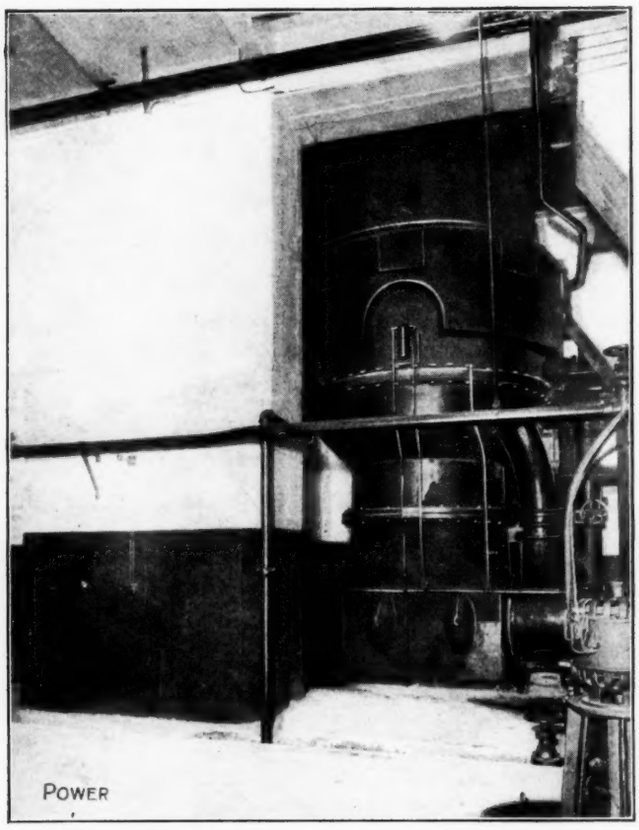


FIG. 3. LEBLANC CONDENSER HUNG FROM THE TURBINE CASING, THUS ELIMINATING THE EXPANSION JOINT FREQUENTLY PLACED BETWEEN THE CASING AND CONDENSER

Hauto reservoir to serve the joint purpose of a cooling pond for the condensing water from the power plant and the storage of an increased water supply for the collieries and other customers of the Panther Valley Water Co.

The new dam was built across the Nesquehoning Creek below the old one. It is made of earth mainly excavated from the power-house site, and is 1800 ft. long, 30 ft. high and 15 ft. wide on the crest; it slopes two to one on both sides. The face on the upstream side is protected by concrete slabs, with the joints between them filled with bitumen. This facing is carried down over the front, forming a concrete cutoff wall that protects the earth part of the dam from contact with the water. At the far end of the dam is a spillway, Fig. 4. It is built as an open flume, with a flat bottom and is designed to carry the maximum recorded flood. It must take care of the water from the watershed above the dam, which has an area of about 10 square miles and furnishes about 4,000,000,000 gal. of water yearly. The water is free from acid, sulphur, etc., as no mine discharge empties into it above the plant.

Condensing water is taken from the lower end of this reservoir through a 13.5-ft. square concrete intake tunnel, which connects with a second tunnel running parallel with the plant and having manholes at convenient intervals. This lateral tunnel is 8 ft. wide and 9 ft. high. Openings 6 ft. high communicate with the intake wells from which 112-ft. lengths of 30-in. cast-iron pipe are carried to the three condensers.

If the water in the reservoir becomes so low during the summer months that the head is insufficient in the intake tunnel, such loss of head will be compensated for by two engine-driven centrifugal pumps housed in the pump house at the edge of the reservoir near the dam and intake tunnel. Each pump has a capacity of 70,000 gal. of water per minute and is driven by a 23x17-in. engine. The 30-in. pipes leading to the condensers have hydraulically operated gate valves, which can be partly closed when the turbines are running with a light load. They can be kept at any desired degree of opening, however, by setting a controlling nut on the extended tail-rod mechanism of the hydraulic cylinder of each valve.

The discharge from the condenser is through about 30 ft. of 30-in. pipe which is carried to the main discharge

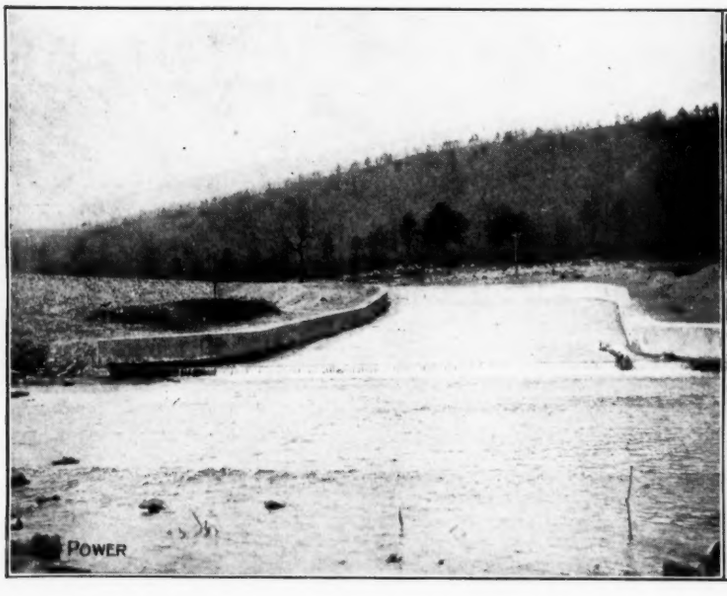


FIG. 4. SPILLWAY AT THE END OF THE RESERVOIR DAM, DESIGNED TO TAKE CARE OF MAXIMUM FLOOD STAGES. THE DAM IS SHOWN AT THE LEFT

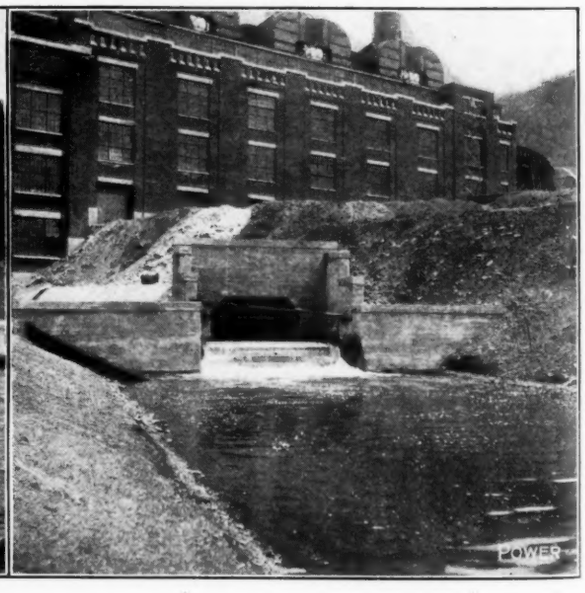


FIG. 5. DISCHARGE PORTAL WHERE THE CONDENSING WATER FLOWS TO THE DISCHARGE CANAL

tunnel extending the length of the turbine room at the back of the condensers in the basement. It is of concrete and is 12 ft. wide, and 15 ft. deep in the center. The discharge outlet, Fig. 5, has a weir with an adjustable crest, which maintains a definite water level on the discharge side of the condensers. This serves to maintain a height of water back of the crest sufficient to keep the end of the 30-in. discharge pipes from the condensers submerged.

A discharge canal conveys the water from the portal of the discharge tunnel to a point at the upper end of the reservoir. The canal is at present 2800 ft. long, but when the plant is enlarged and more cooling surface is required in the reservoir, the discharge outlet will be carried further up the valley to a point about 6500 ft. above the intake tunnel. This will give the water time to cool before it is again used in the condensers.

The next installment of this description will deal with the boilers, the forced-draft system, and the method employed in handling the coal and ash.

PRINCIPAL EQUIPMENT OF THE HAUTO STEAM-ELECTRIC POWER PLANT OF THE LEHIGH NAVIGATION ELECTRIC CO.

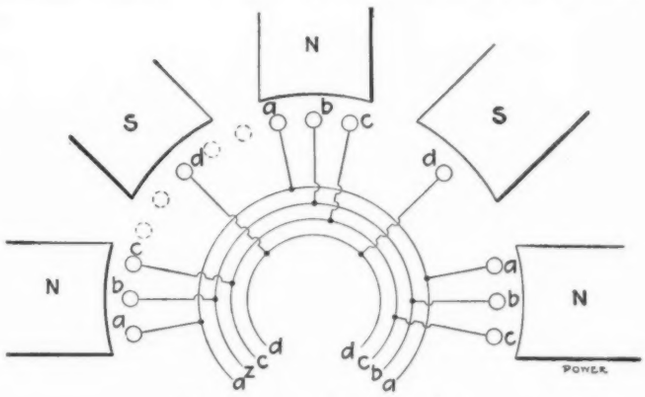
No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Turbines	G.E., horizontal	12,500 kw.	Main units	225 lb. steam, 100° F. superheat, 1500 r.p.m.	General Electric Co.
3	Generators	Alt. current	12,500 kw.	Main units	1500 r.p.m., 3-phase, 25 cycles	General Electric Co.
3	Generators	Direct current	300 kw.	Exciter units	1800 r.p.m., 250 volts, one 750 r.p.m.	General Electric Co.
2	Turbines	G.E., horizontal	300 kw.	Driving exciter units	1800 r.p.m., 225 lb. steam	General Electric Co.
1	Motor	Induction	450 hp.	Driving exciter unit	750 r.p.m., 250 volt	General Electric Co.
3	Condensers	Leblanc	No. 24	Main turbines	28-29 in. vacuum	Westinghouse Mch. Co.
3	Turbines	Single stage	445 hp.	Condenser pumps	700 r.p.m., 225 lb. steam, 100 deg. superheat	Westinghouse Mch. Co.
8	Boilers	B.&W. low W	1000 hp.	Steam generators	225 lb. steam, 100 deg. superheat	Babcock & Wilcox
24	Grates	Hand fired, dumping	8x12 ft.	Boiler furnaces	Hand firing	Acme Furnace Equipment Co.
8	Grates	Automatic traveling	7x12 ft.	Boiler furnaces	Automatic stoking	Coxe Travelling Grate Co.
3	Fans	Sirocco	6 ft. No. 12	Forced draft	360 r.p.m., motor driven	American Blower Co.
3	Motors	Induction	450 hp.	Driving draft fans	360 r.p.m., 2300 volts, 3 phase, 25 cycles	General Electric Co.
3	Turbines	Single stage	125 hp.	Driving boiler-feed pumps	2900 r.p.m., 225 lb. steam	Terry Steam Turbine Co.
3	Pumps	Centrifugal	4-in.	Boiler feed	2900 r.p.m., turbine driven	Henry R. Worthington
5	Pumps	Reciprocating	8x12x14x12 in.	Feedwater and priming	Low head	Henry R. Worthington
2	Injectors	Compound		Auxiliary boiler feed	Emergency	Eynon-Evans Mfg. Co.
16	Meters	Venturi	3 in.	On boilers	Continuous	Builders Iron Foundry
2	Meters	Venturi	6 in.	On boiler main feed line	Continuous	Builders Iron Foundry
2	Pumps	Centrifugal	48 in.	Emergency condensing water	In use during low water	Alberger Pump & Condenser Co.
2	Engines	Reciprocating	23x17-in.	Driving emergency pumps	In use during low water	McIntosh & Seymour Engine Co.
2	Motors	Induction	10 hp.	Driving sump pump	Intermittent service	Westinghouse Elec. & Mfg. Co.
9	Transformers	Oil cooled	3350 kv.a.	Step-up 11,000 to 110,000 volts	25 cycles, 3-phase, 11,000-110,000 volts	General Electric Co.
9	Switches	Oil	110,000 volt	High-tension circuits		General Electric Co.
1	Crane	Traveling	110 ton	Turbine room	Motor, operated	Whiting Foundry Equipment Co.
1	Pump	Vertical, duplex	7x5x12 in.	Oil system	Intermittent	Dean Bros. Steam Pump Co.

Equalizing-Ring Requirements

Multiple-connected generator armatures have as many independent current paths from machine terminal to machine terminal as there are field poles in the machine. The distribution of the total current in the several independent armature paths is affected by ununiform distribution of the air gap around the armature, so that part of the armature conductors run in a denser field than another; ununiform resistances of contacts between the brushes of different holders and the commutator, so that the resistance of one independent path may be higher than that of another; and ununiform spacing of the several sets of brush-holders, so that the e.m.f. across one set of holders may be greater than that across another set of holders. To minimize the effects of slight ununiformities, armature conductors that should be at the same potential at the same time are sometimes connected by means of conductors called "equalizers."

The general plan of equalizing by means of such rings is indicated in the accompanying sketch in which part of an eight-pole generator is shown. Here it will be noted that conductors occupying a given position relative to a pole piece of certain polarity are connected to a bus-ring to which are also connected all other conductors similarly situated with regard to a polepiece of the same polarity. On modern generators all equipotential armature conductors may be found to be equalized; on others, they may be equalized only at certain intervals; on still others, there may be no equalizers. In any event, the full possibilities of equalizing connections cannot be realized unless the number of poles and the taps and the total number of armature conductors involved are so related that the taps may be exactly equispaced.

In a case in mind, a multipolar machine that had no equalizers sparked because of unequal distribution of current among brush-holders; the operator installed equalizing rings, but this did not seem to give any relief. Investigation revealed that the relation between the number of poles and the conductors was such that equal spacing of the equalizer taps was impracticable. Equalization was finally improved by adjustments of the air gap, the brush tensions and the brush spacings.



EQUALIZING CONNECTIONS

Skill as an Asset—As a man remains in the employ of a firm so his particular skill on his job increases. This skill does not represent an item of cost to the firm, but it does represent an asset; his skill and knowledge are direct money value to the shop where he is employed, and his departure diminishes the capital of the firm by that amount. This value can never be expressed directly in dollars and cents. If it could be, many a manager would think twice before laying off men.—"American Machinist."

Draft for Smokeless Combustion*

By Osborn Monnett†

SYNOPSIS—Breeching area, stack area and height and the proper draft over the fire to burn smokelessly Western bituminous coals or shavings.

Breeching Area

With water-tube boilers it is good practice to allow a ratio of breeching area to grate surface of 1 to 4½ or 5. In large central stations a ratio of 1 to 3½ has been used where the boilers are run habitually at 100 per cent. over rating, but this is a special study not considered in the present article. The ratio of 1 to 4½ or 5 for rated capacities is based on a gas travel of approximately 18 ft. per sec. with a breeching temperature of 500 deg. F. This will give a maximum gas travel of about 28 ft. per sec. for a 50 per cent. overload and will provide sufficient area to take care of ordinary fluctuations in load.

Theoretically the loss in a horizontal run of breeching will be about 0.1 in. of water per 100 ft. of length. In practice, this can well be doubled, due to accumulations in the breeching, loss by radiation, leaks, etc., remembering that the designer should figure the breeching to meet the most adverse conditions likely to be encountered.

Breechings should be well lagged to prevent radiation, and the covering should be placed on the outside, so that it will be in plain sight and need for repair can be

NO.1 BOILER	BEFORE	AFTER
Over Fire	0.16"	0.26"
Flue Cap Door	0.26"	0.39"
Stack Side of Damper	0.34"	0.46"
NO.2 BOILER		
Over Fire	0.20"	0.32"
Flue Cap Door	0.33"	0.43"
Stack Side of Damper	0.43"	0.51"
Base of Stack	0.60"	0.60"

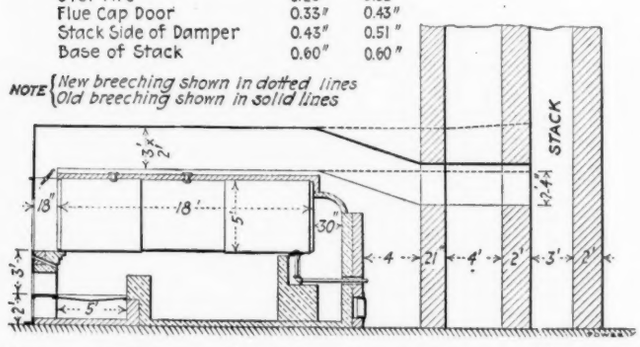


Fig. 1. Showing Detrimental Effect of Drop in Breeching

easily seen. A lining on the inside is difficult to repair and deterioration might readily escape detection.

The loss in a right-angle bend can be taken as 0.05 in. of water. Under no circumstances should the breeching take a drop below the horizontal. Fig. 1 illustrates the detrimental effect of such a drop and gives the draft readings before and after making the change which affected the available draft over the fire approximately 100 per cent. Sacrifice everything to a straight, uninterrupted run of breeching. Do not allow conduits, ventilating ducts, etc., to take precedence in a matter which vitally affects the plant during its entire life. Loss of draft through a breeching should be figured from the boiler farthest from the stack. Each additional boiler connected to the breeching will cause a drop, due to the friction or interference of the gases as they enter the breeching, or to leakage through the damper when the boiler is out of service. This additional draft loss may be taken at 0.05 in. of water per boiler connected to the breeching. Any bends in the breeching should be eased off in long sweeps and the stack connection should be at an angle of 45 deg.

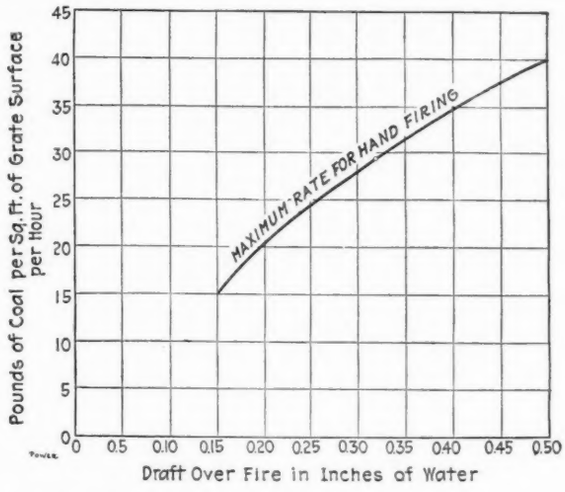


Fig. 2. Draft Intensity for Smokeless Combustion

Draft vs. Rate of Combustion

In practice, it has been found that the draft over the fire required to burn Western bituminous coals in well designed smokeless furnaces is approximately 0.01 in. of water per pound of coal. When burning 15 lb. of coal per square foot of grate surface per hour this ratio holds exactly. As the combustion increases, the draft is a little greater in proportion. This is shown in Fig. 2. For instance, at 21 lb. of coal the draft is 0.205 in.; at 30 lb. it is 0.33 in., and at 40 lb. the draft is 0.5 in. It must be understood that the curve is for the ordinary run of bituminous coal when considered from the standpoint of smoke suppression. Free burning coal of this character will burn after a fashion with less draft; that is, the fixed carbon will be consumed, but most of the volatile matter will pass off unconsumed and will make a great deal of smoke.

The draft curve shown has been obtained by averaging thousands of draft readings in plants burning Western bituminous coals smokelessly. While the drafts given may seem excessive to some engineers, yet experience has shown that they are necessary to get the best results.

Burning Shavings

Shavings will burn satisfactorily with half the draft required for coal; that is, 0.005 in. of draft per pound of dry shavings per square foot of grate surface per hour, provided they are fed through a chute by a blower. This holds good up to 0.6 in. of draft over the fire, which is sufficient for 120 lb. of dry shavings per square foot of

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†Smoke Inspector, city of Chicago.

grate per hour. Wet, fine shavings and sawdust, hand fired, or a mixture of shavings and coal require approximately the same draft over the fire as coal alone. In designing a new plant it is, therefore, advisable to provide for the maximum draft to take care of emergencies.

Stack Dimensions

In analyzing the draft conditions in several hundred plants it was found that a stack area of one-fifth of the connected grate surface gave the best results. This ratio provides a gas velocity in the stack of about 30 ft. per sec. at maximum loads. A ratio of 1 to 6 has been employed with success in many installations, and with exceptionally high stacks, such as are found in skyscrapers, 1 to 7 is allowable. For the ordinary commercial plant, a ratio of 1 to 5 is much better and will give sufficient capacity for peak loads and smokeless operation.

The following formula given in "Stirling" for draft intensity has worked out well in practice:

$$D = 0.52\ H \times P\left(\frac{1}{T} - \frac{1}{T_1}\right)$$

where

D = Draft in inches of water;
H = Height of top of stack above grate bars in feet;
P = Atmospheric pressure in pounds per square inch;
T = Atmospheric temperature, absolute;
T_1 = Absolute temperature of stack gases.

At ordinary altitudes, variations in the atmospheric pressure may be disregarded, but where the plant is at a high elevation it is best to use in the formula the corresponding air pressure.

For the usual sea-level air pressure of 14.7 lb. and a temperature of 60 deg. F., the formula may be reduced to $D = KH$ where

$$K = 0.52 \times 14.7\left(\frac{1}{T} - \frac{1}{T_1}\right)$$

This necessitates the computation of values for constant K for various flue-gas temperatures such as are given in Table 1.

TABLE 1. VALUES OF CONSTANT K FOR VARIOUS FLUE-GAS TEMPERATURES

Temperature of Stack Gases Deg. F.	K
750	0.0084
700	0.0081
650	0.0078
600	0.0075
550	0.0071
500	0.0067
450	0.0063
400	0.0058
350	0.0053

Then to find the draft in inches of water it is only necessary to multiply the height of the stack in feet by the constant corresponding to the temperature of the stack gases. Conversely, to find the height in feet of a stack to produce a certain draft, divide the draft in inches of water by the constant corresponding to the flue-gas temperature.

A stack temperature of 500 deg. is seldom exceeded and 475 deg. is a good average figure, owing to the various losses which occur between the boiler uptake and the stack.

Table 2 may also be used to determine the size of stack for horizontal tubular boilers. The dimensions given, however, apply only when the boilers are connected to the chimney by a straight run of breeching which has fully as much area as the stack and in which long narrow sections are not used and sudden changes of section are avoided.

TABLE 2. SIZES OF CHIMNEY FOR HORIZONTAL RETURN-TUBULAR BOILERS

Size of Boiler	Number of Boilers on Stack: One	Two	Three	Four	
48″x14′	21½″x90′	30″x100′	37″x110′	42½″x120′	34-3½″ tubes
54 x16	24½ x95	34½x105	42½x115	49 x125	34-4″ tubes
60 x16	28½ x100	40 x110	49 x120	57 x130	46-4″ tubes
66 x18	31 x110	43½x120	53½x130	61½ x140	54-4″ tubes
72 x18	35 x120	49½x130	60½x140	70 x150	70-4″ tubes
78 x20	39½x130	56 x140	68 x150	78½ x160	84-4″ tubes

Economical Auxiliaries in a Refrigerating Plant

By K. M. Gilbert

SYNOPSIS—Reduction in fuel consumption resulted from the use of economical auxiliaries. A jet condenser and cooling tower were replaced by an atmospheric steam condenser; belt-driven pumps were used instead of duplex steam pumps. Power for auxiliaries is obtained from the main engine. Steam trap for feeding boiler.

The chief engineer of a small refrigerating plant "made good" by giving much time and study to improvement in the efficiency of the auxiliaries. When the engineer took charge of the plant, the machinery consisted of:

One 100-hp. return-tubular boiler; 130 lb. pressure.

One 12 and 24 by 21-in. tandem compound Corliss engine, directly connected to two single-acting 14x21-in. ammonia compressors.

One 8 and 12 by 12-in. vacuum pump with jet condenser.

One 6 and 7 by 6-in. duplex pump for cooling water to ammonia condensers.

One 4½ and 2¾ by 4-in. feed pump.

One 6 and 6 by 6-in. air compressor.

These pumps were all necessary for the operation of the plant. There were also one or two other small pumps used occasionally.

The amount of water available was so small that it was necessary to use two cooling towers; one for the steam condenser and the other for the ammonia condenser water. The main engine was run condensing, the vacuum being obtained by means of the jet condenser and pump which discharged the condensing water to the top of the 30-ft. cooling tower.

The exhaust from all but the condenser pumps was discharged through the feed-water heater into the atmosphere. The amount of heat in the exhaust was more than could be used in the feed water, so the surplus

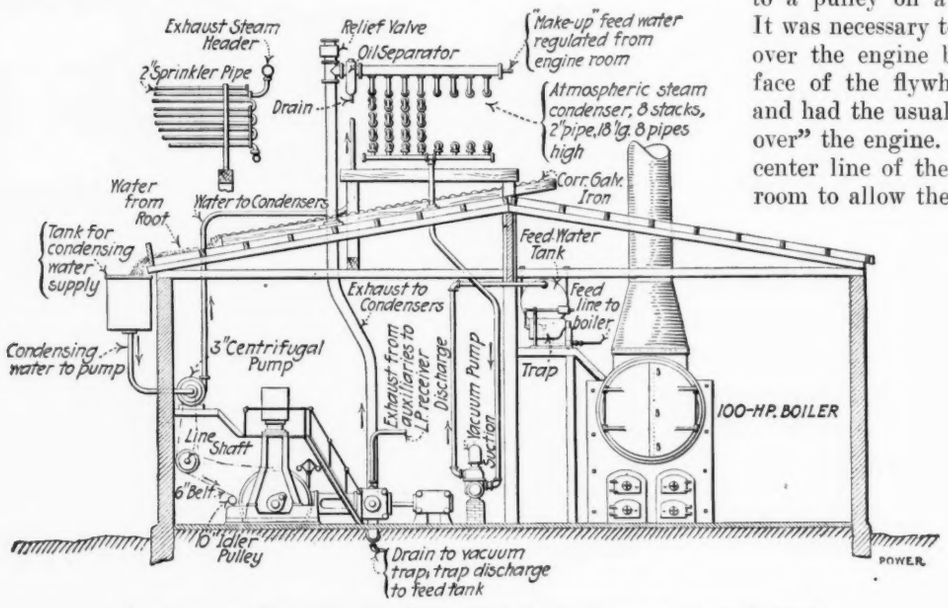
steam passed off to the atmosphere and considerable heat was wasted.

The horsepower and steam consumption per hour of the main engine and auxiliaries were as follows:

Main engine	100 hp. at	18 lb. steam per hp.-hr.	= 1800
Jet condensing pump	6 hp. at	80 lb. steam per hp.-hr.	= 480
Feed pump	1½ hp. at	100 lb. steam per hp.-hr.	= 150
Ammonia condenser pump	6 hp. at	90 lb. steam per hp. hr.	= 540
Air compressor	6 hp. at	40 lb. steam per hp.-hr.	= 240
		Total steam consumption per hr.	= 3210

Coal burned per hr. = about 400 lb.

The plant was operated with this machinery for one season, during which time the chief carefully studied all the faults of the plant and came to the conclusion that the high fuel consumption was due entirely to the inefficient auxiliaries. The management had complete confidence in the engineer, so that when fall came he was able to start in and make all of the changes which he had studied out to give the best economy. The sketch



LAYOUT OF ICE PLANT, SHOWING LOCATION OF AUXILIARIES

shows the arrangement of the machinery at the beginning of the second year.

The jet condenser was replaced by an atmospheric steam condenser made from an ammonia condenser. This type of steam condenser gives pure water for boiler feed, takes less horsepower for operation and does not require the use of a cooling tower. The connections from the condenser to the engine and to the vacuum pump are shown. The water for condensing the steam was pumped by a 3½-in. centrifugal pump, which discharged the water into a 2-in. pipe placed over each section of the condenser. On the top of these pipes were drilled ⅜-in. holes 4 in. apart, through which the water flowed over the condenser pipes and thence to the roof. A suitable gutter and lead pipe conducted the water into a tank, as shown, to which was attached the suction of the centrifugal pump. The condenser was drained by a 6 and 7 by 10-in. single-cylinder pump, which discharged into a 42-in. by 8-ft. horizontal feed tank placed above the boiler.

Small boiler-feed pumps consume a large amount of steam for the work done and, in addition, require oiling, packing and considerable attention. I believe a steam trap is the cheapest method of feeding boilers. The temperature of the water and any irregularity in the feed has no effect upon the proper working of the trap. By reference to the sketch, the relative location of the feed tank, the trap and the boiler can be seen. The volume of the steam used by the trap for each discharge is equal to the volume of the trap, and when the trap has discharged its contents into the boiler, the steam contained in the trap is discharged into the feed tank.

The 6 and 7 by 6-in. duplex steam pump for pumping water to the ammonia condensers required 540 lb. of steam per hour. This was a large amount of steam for the work done and just how to reduce this item of expense caused the engineer considerable worry. Finally, he decided to install a 7x8-in. triplex pump. The power for driving this pump, and also that for the centrifugal pump, for water to the steam condensers, was derived from the main engine. By reference to the sketch, it will be seen that a 6-in. belt was run over the flywheel to a pulley on a line shaft back of the engine. It was necessary to use an idler to guide the pulley over the engine bedplate onto the flywheel. The face of the flywheel was flat, about 14 in. wide and had the usual 2-in. square holes for "pinching over" the engine. The belt ran on one side of the center line of the rim so that there was sufficient room to allow the pinching bar to enter the holes.

The idler pulley did not give the least bit of trouble and, furthermore, it was useful in guiding the belt onto the wheel, for, by simply changing the position of the ball-and-socket bearings for the idler shaft (by use of the setscrews), the belt could be made to run on any part of the flywheel rim. The pulley on the line shaft was fitted with a friction clutch, enabling the engineers to stop the line shaft without shutting down the main engine. In addition to the reduction in steam consumption, the triplex pump required less oil and less packing and repairs than were necessary to operate the duplex pump, with its multiplicity of rods and valve-gear parts.

The exhaust steam from the 6 and 6 by 6-in. air compressor and the 6 and 7 by 10-in. vacuum pump was more than could be used in the feed-water tank. In order that no steam should be wasted, the exhaust from the air compressor was discharged into the low-pressure receiver to do work in the low-pressure cylinder, and was exhausted into the main steam condenser. A 1-in. pipe was run from the receiver to the feed-water tank to supply steam to the feed water when the exhaust steam from the vacuum pump was insufficient to heat the water to about 210 deg. F.

After making these changes, as illustrated, the steam consumption and horsepower of the various units were as follows:

			Lb.
Main engine	110 hp. at	18 lb. steam per hp.-hr.	= 1980
Vacuum pump	2½ hp. at	90 lb. steam per hp.-hr.	= 225
Air compressor	6 hp. at	45 lb. steam per hp.-hr.	= 270
		Total steam consumption per hr.	= 2475

Coal burned per hr. = about 300 lb.

By comparing these figures with the foregoing, both of which were obtained by actual test, it is seen that the new system of auxiliaries reduced the coal consumption 100 lb. per hour, or 2400 lb. per day, which at $3.20 per ton makes a daily saving of about $3.50. The plant was operated at full load 300 days in the year, so that the fuel saving amounted to more than $1000. The cost of making the changes was $1200, so that the interest on the investment was more than 80 per cent.

The arrangement of the machinery, as shown in the sketch and described above, was, to the writer's knowledge, successfully used for three years. During this time, no serious trouble was experienced. The steam condensers gave a vacuum of 22 to 24 in. in the hottest weather, and a supply of pure feed water for the boilers. The makeup feed water amounted to about 150 lb. per hour. As this was the only source by which impurities could enter the feed water, it is evident that no trouble whatever was had with boiler scale. The condensing water, in passing over the condenser tubes, was heated and some of it evaporated. The loss of condensing water, by evaporation, was just about equal to the amount of steam condensed, which, in hot weather, varied from 2000 to 2500 lb. per hour. Attention should be called to the fact that with this type of steam condenser it does not take any more water to run an engine condensing than it does noncondensing, with the steam escaping to the atmosphere. The amount of water saved by condensing the steam is, as noted, about equal to the amount of makeup water supplied to the condensing water to replace that loss by evaporation, but more of the heat in the exhaust steam is being returned to the boiler.

The Fulton Oil Engine

Notable as the first Diesel engine of American design to be put out in sizes as small as 50 hp., is that recently built by the Fulton Manufacturing Co., Erie, Penn., and shown in Fig. 1. The engine is designed primarily for marine service and operates on the four-stroke cycle. In the 50-hp. size three cylinders are employed, four for 70 hp. and six for 100 hp., all 8x9 in.

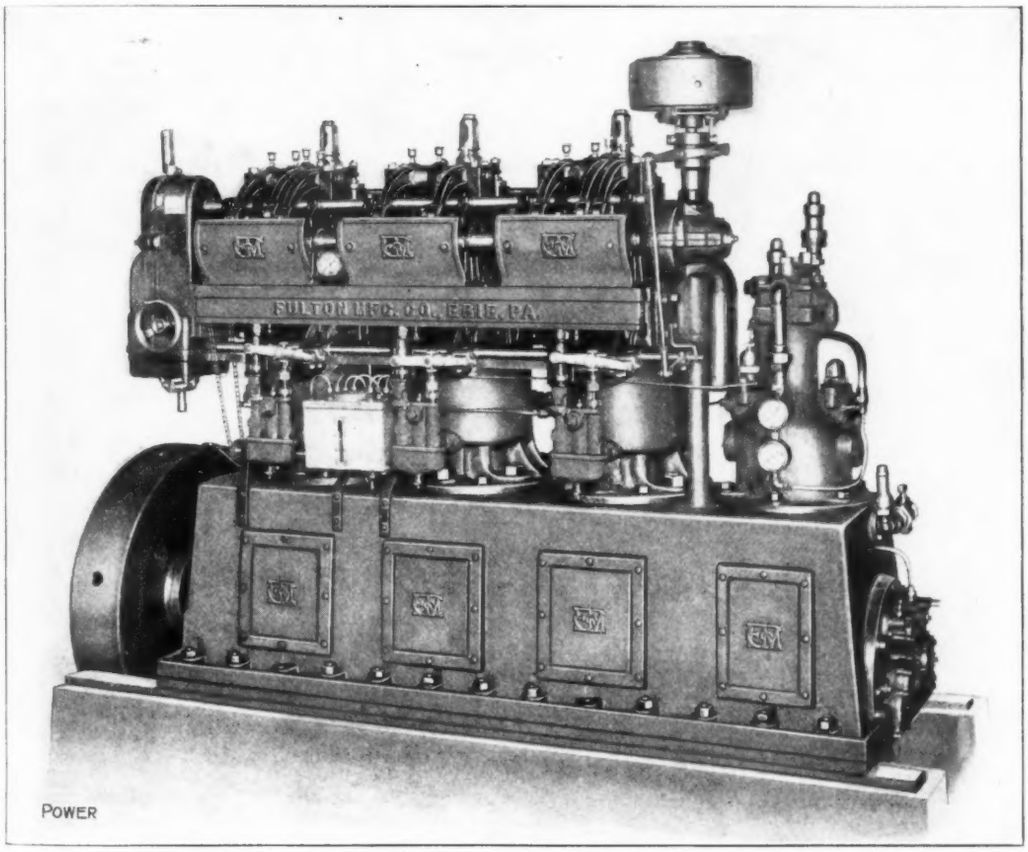


FIG. 1. 50-HP. THREE-CYLINDER FULTON ENGINE

The arrangement is such that any cylinder head may be removed without disturbing the camshaft which is mounted on ball bearings and is driven from the crankshaft by an intermediate vertical shaft with helical worm gears. The cam levers are of cast steel, with hardened tool-steel rollers and pins with screw adjustment for clearance at the tappet ends. The suction and exhaust valves, in the cylinder head, are of tungsten steel and interchangeable.

AIR COMPRESSOR

The air compressor is on the center line and at one end of the engine, being driven directly from the main shaft. It is of the two-stage type, as shown in Fig. 2. Free air is drawn into the lower cylinder through the strainer and duplex suction and delivery valve, and is compressed to about 120 lb. It is then delivered to the intercooler (the coil at the right), thence to the high-pressure or upper cylinder. From here it passes to a second cooler and finally to the receivers for fuel injection. Slightly more air is delivered than is necessary for fuel injection and this surplus is carried to two larger receivers, of 2458 cu.in. each, for starting. The pressure for fuel injection is regulated by hand according to the load, full load requiring about 975 lb., half load about 800 lb. and 10 per cent. overload, 1000 lb. Both the suction and the delivery valves in the high-pressure head are supplied with renewable seats and can be inspected without disturbing any of the pipe connections.

The fuel-injection valve and atomizer are in the cylinder head. The body is of bronze and the needle valve of nickel steel. A heavy compression spring closes the valve and it is forced open by a cam lever. Referring to Fig. 3, it will be seen that the oil is delivered on one side, passing down to the lower part of the atomizer.

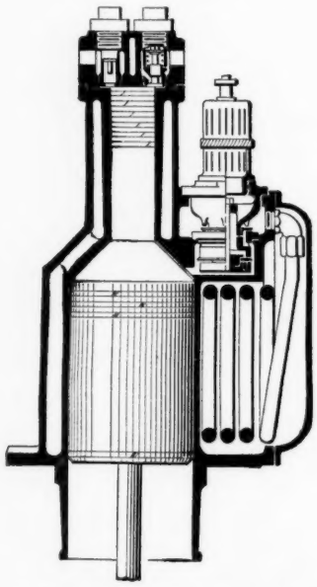


FIG. 2. SECTION THROUGH COMPRESSOR

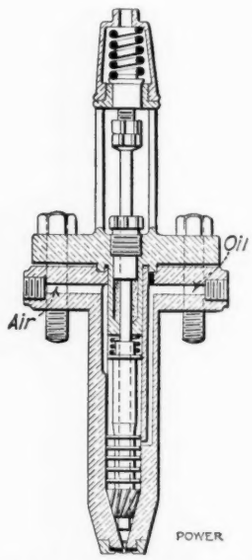


FIG. 3. FUEL VALVE AND ATOMIZER

Air is admitted on the opposite side, but is led to the upper part of the atomizer behind the oil. Atomizing is effected by the perforated disks, and when the needle valve is raised the oil is blown into the compression space of the cylinder, in finely divided particles where it is ignited by the heat of compression. The grooves at the lower end impart a whirling motion to the injection air, which tends to clean out all the fuel, besides having a tendency to complete the breaking-up process begun by the perforated disks.

FUEL PUMP

On the three-cylinder engine shown in Fig. 1 there are three separate fuel pumps, one for each cylinder. In the later design, however (Figs. 4 and 5), one fuel-pump unit serves three cylinders. Referring to Fig. 5, it will be seen that this unit has three displacement plungers

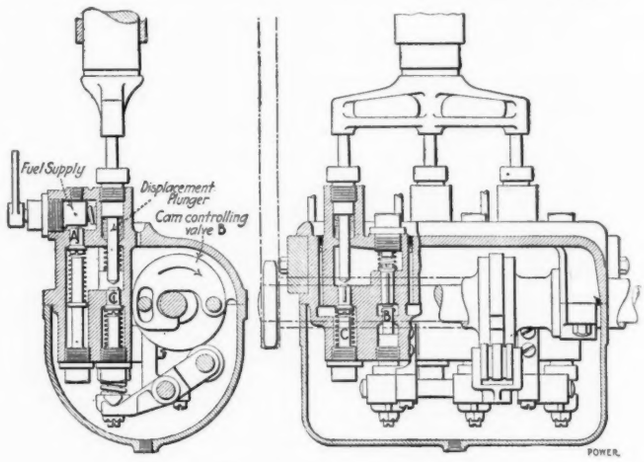


FIG. 5. FUEL PUMP

and three separate sets of valves, one for each cylinder. On the suction stroke of the plunger, oil enters the pump chamber through the suction valve *A*. On the delivery or downward stroke this fuel is bypassed through the control valve *B* (shown in the right-hand view). When this control valve is closed the charge is forced through the delivery valve *C* to the fuel atomizer. The amount of fuel fed to the cylinder, and hence the speed of the engine, depends upon the action of the control valve *B*; that is, while the stroke of the displacement plunger is constant, the amount of oil bypassed through valve *B* determines the amount supplied to the cylinder. The timing of this valve is accomplished by means of a sliding cam which rotates at a speed determined by the engine, but the position at which it becomes effective is subject to the movement of the governor arm.

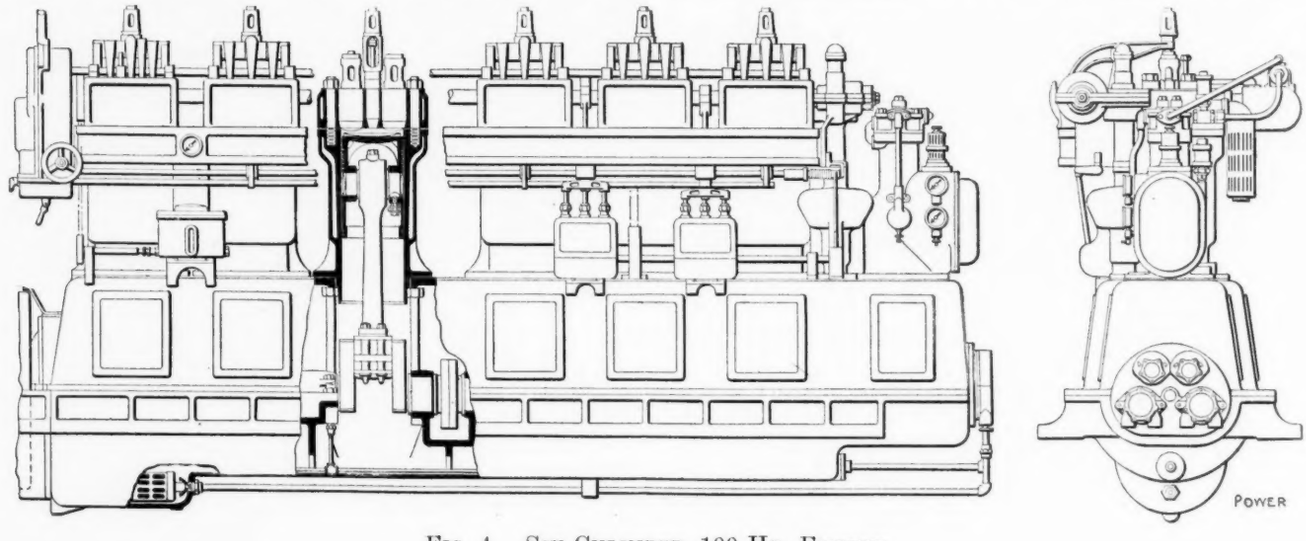


FIG. 4. SIX-CYLINDER, 100-HP. ENGINE

To render the pump inoperative, as is required when wishing to cut out a cylinder, means are provided for holding open the suction valve. The fuel pumps may be operated by hand without disconnecting from the drive. An inclosed fly-ball type of governor is employed.

LUBRICATION AND CONTROL

Forced lubrication is supplied to all of the crankshaft

bearings and wristpins. The crankshaft is drilled through its entire length and a small, self-priming rotary pump circulates the oil from the engine bed to all the bearings inside the crank case and up through the hollow connecting-rod to the wristpin. An overflow valve regulates the pressure, which is normally held at 15 lb. In addition, there are attached to each working cylinder two feeds and one to the air compressor, from a force-feed oiler.

A handle and handwheel at the front of the engine, supplemented by interlocking push buttons, provide the operator with the necessary means for easy control. The handle has three positions: "barring," "air start" and "running," the buttons being so interlocked with the handle that starting air and fuel cannot be supplied to a given cylinder at the same time.

The cylinders upon which the air start is provided must be bypassed before the starting handle can be placed in the "air start" position. With the handle in the barring position all the fuel is bypassed so that should the engine be turned over a number of times the cylinders cannot become flooded with oil. The handwheel serves to put more or less load on the governor, thereby increasing or decreasing the engine speed.

Turbine-Valve Lubrication

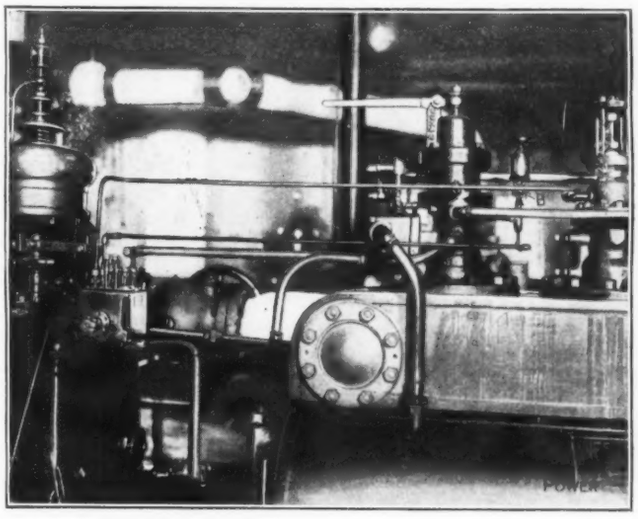
By Paul B. Prutzman

The primary and secondary valves of a Westinghouse turbine need little lubrication, and this is usually supplied by means external to the turbine itself. I have found that the force-feed cylinder-oil pump, which is commonly used on the valves of a reciprocating engine can be used satisfactorily and at a saving in cost of oil, which, if figured by the year, will more than offset the cost of the pump and all attachments.

The idea of coupling one of these pumps to a turbine came to the writer after having taken charge of a central station in the eastern part of Pennsylvania consisting entirely of Westinghouse turbines. Naturally the condensed steam was used for boiler feed and it was necessary to keep it as free from oil as possible. In this respect the force-feed pump caused no trouble. Heretofore the valves were lubricated by means of the small brass cup shown at *A*, which holds about a quarter of a pint. As soon as the valve *B* was opened, admitting pressure, no matter how little, all of the oil was immediately forced into the turbine valve, thereby wasting a large percentage of it without mentioning the damage to the boilers from oil in the condensate. The cup was not refilled for four to six hours, or until the engineer thought the valve might need it.

Considerable trouble from sticking valves led me to try a new method. A force-feed pump was obtained on 60 days' trial and was given a thorough test under the most trying conditions. To mount the pump a suitable bracket was made and bolted to the bearing cap nearest the governor gear case. It extended out on the side so as to bring the pump in line with the oil pump supplying the turbine bearings. It was necessary to bring it above the bearing cap about 18 in., so that the connecting-rod, when in motion, would clear all parts of the turbine. The crosshead pin in the turbine oil pump was drilled for a ⅜-in. capscrew, and this screw acted as the main driving pin for the cylinder oil pump. The operating lever was made at first 6 in. long, but as this made the feed too fast, it was increased to 12 in., which proved about right. The operating lever had a 120-deg. throw and the turbine oil-pump plunger an 8-in. stroke, with 80 strokes per min., so that the feed could be brought down considerably. The connecting-rod being attached to the operating lever with an adjustable thumb-screw, it was an easy matter to increase the feed while running, and adjustment was also possible by means of the small thumb-screw on the pump deck controlling the feed. The former method is preferable on account of the size of the drop remaining the same.

One of the principal advantages arising from this method of lubrication is the regularity with which the valve will receive its supply of oil. I have found that a



Oil Piping to Turbine Valves

drop about the size of a match head every 3 min. is sufficient to keep the valve in perfect condition, regardless of the changes in load. As an indication of the saving in oil it may be stated that heretofore a quart of oil usually lasted about 24 to 30 hr., while with the pump in use it lasts for about 110 hr. of continuous running.

It is necessary to have two feeds on the pump so as to lubricate both the primary and secondary valves of the turbine, but as the pumps are usually made with two or more feeds, this did not prove a disadvantage. As the secondary valve only comes into play at full load or on overload, it can be shut off by means of the small screw on the feed plunger until it is needed, and then by a half turn of this screw it can be easily brought into action.

The photograph shows the sight-feed pump, and the ⅛-in. piping to the two valves. There is a check valve in each line close to the valve. As the valve uses up about all the oil that is fed to it, the condensed exhaust steam contains very little oil.

Temperatures of High-Speed Generators

By J. M. Long

Temperature is an important item which requires close attention in the operation of high-speed generators, particularly of the steam-turbine-driven and large high-speed waterwheel-driven types. This is necessary for the reason that, in the design of such apparatus, the windage developed by the high speed of the rotor is depended upon largely for the proper ventilation of the generator.

The ordinary method of reading temperature by placing thermometers in different parts of a generator seems insufficient, except perhaps to ascertain the approximate temperature of the iron. With the machine in operation, thermometers placed against parts of the winding that are accessible register temperatures of air in motion adjacent to the winding rather than the internal temperature of the armature coils.

Furthermore, temperature readings thus obtained with the machine standing still are too low, because the rate of cooling from a high temperature is so rapid after the load has been taken off that by the time the rotor has been brought to rest, it is impossible to determine what the temperature was under full-load conditions.

The average internal temperature of an armature winding may be found by measuring the resistance of the armature, cold and hot, and applying a formula based on the temperature coefficient of copper and thermometer readings of the cold armature. But this method is insufficient for the same reason as given with reference to the rapid rate of cooling after the load is taken off. It is impossible to obtain hot resistance measurements under full-load conditions.

Another method, which seems best adapted to measuring the temperature under full-load conditions, is by the employment of temperature-measuring coils, noninductively wound. These may be placed between coils, or between the coils and the iron, in the slots of an armature where the highest temperatures obtain. It is by measuring the resistance of these coils that accurate temperatures may be determined in the armature of a high-speed generator under full-load conditions.

The accompanying data, derived from the temperature test of a 12,000-kw., high-speed generator, is illustrative of the three different methods employed in the same heat run. While the summary of results indicates that the different methods in themselves may be accurate and check within a few degrees, it will be noted, by reference to the column headed, "Rate of Cooling," that during the one hour elapsed between the time the generator was fully loaded and the time all tests were completed after the generator had been brought to a standstill, the armature had cooled off approximately 35 deg. C.

This substantiates the contention that it is practically impossible to measure accurately the internal temperature of an armature operating under full-load conditions by the thermometer and resistance methods.

Eleven thermometers were distributed in different parts of the armature so as to measure the average temperature of the coils, except that thermometers 1, 2, 3 and 4 were in the same location. The eight temperature coils, also distributed in different parts of the armature, were of a standard make, were calibrated at a known temperature before being put into the machine, and were connected with a reliable instrument which registered the degrees Centigrade.

The results of temperature measurements in electrical apparatus are apt to be misleading when derived under any other condition than that of full load; and the only way of determining temperatures under such conditions seems to be with temperature coils so arranged that changes in their resistance, as affected by heat, may be measured and reduced to degrees of temperature.

TEMPERATURES OBTAINED BY THERMOMETER, RESISTANCE AND TEMPERATURE-COIL METHODS

Armature—Hot

Armature Phases	Current Amp.	Drop Millivolts	Resistance Ohms	Thermometers No.	Thermometers Deg. C.	Coils No.	Coils Deg. C.
A - B	3.56	83.0	0.02331	1	65	1	71.5
A - B	7.64	184.0	0.02408	2	63	2	73.0
A - B	7.00	169.8	0.02426	3	65	3	62.8
A - B	3.92	144.2	0.02436	4	67	4	73.5
				3	65	5	62.0
A - C	5.00	120.0	0.02400	6	63	6	63.9
A - C	6.00	145.2	0.02420	7	67	7	62.5
A - C	7.70	185.8	0.02413	8	67	8	63.0
				9	65		
B - C	5.00	120.0	0.02400	10	67		
B - C	6.02	145.5	0.02417	11	66		
B - C	7.70	185.7	0.02412				
		Averages	0.02406		65.5		68.5

$$t_2 = (238 + t_1)\frac{R\,t_2}{R\,t_1} - 238$$

t_1 = temperature cold
t_2 = temperature hot
Rt_1 = resistance at t_1
Rt_2 = resistance at t_2

Resistance Temperature per Formula	Based on Cold Thermometer Readings	Based on Cold Bulb Readings
	64	64.8

Armature—Cold

Armature Phases	Current Amp.	Drop Millivolts	Resistance Ohms	Thermometers No.	Thermometers Deg. C.	Coils No.	Coils Deg. C.
A - B	3.16	68.5	0.02168	1	*31	1	38
A - B	4.96	108.0	0.02177	2	*30	2	36
A - B	7.14	159.0	0.02227	3	*30 (30)	3	36.5
				4	*30	4	39
A - C	3.14	69.0	0.02196	5	36	5	37
A - C	4.98	108.5	0.02178	6	38	6	37
A - C	7.06	153.0	0.02167	7	..	7	38
				8	38	8	37
B - C	3.16	69.0	0.02183	9	37		
B - C	4.98	108.1	0.02171	10	38		
B - C	6.80	147.0	0.02162	11	39		
		Averages	0.02181		36.6		37.3

Rate of Cooling Condition	Time	No. 2 Bulb
Loaded	9.20	101
Load off	9.23	
Off line	9.25	97
	9.30	92
	9.35	90
Stopped	9.36	
Field off	9.37	
	9.40	87
	9.45	84
	9.50	81
	9.55	79
	10.00	77
	10.05	76
	10.10	75
	10.15	71
	10.20	66

Summary

Resistance temperature based on cold thermometer readings	64.0
Resistance temperature based on cold bulb readings	64.8
Temperature per hot thermometer readings	65.5
Temperature per hot generator bulb readings	68.5

*Thermometers 1, 2, 3, and 4 in same location near air inlet with manhole cover off. Cold readings figured as of one thermometer.

Burning Fuel Oil under Boilers

By W. G. Greenlees

SYNOPSIS—Some practical experience with the burning of fuel oil, and the various methods employed. The use of targets is condemned. A burner which will spread the flame at the front is recommended and a fire floor level from front to back.

When fuel oil was first discovered in Texas in large quantities, this entire section of the country was at once given the advantages of cheap fuel. However, instead of applying this cheap fuel in such a way as to obtain a high efficiency in its use, in many plants, especially small ones, the simplest possible method of oil burning was adopted. Some of these methods were crude in the extreme and inefficient. It was not uncommon to see in a laundry, well drilling rig or other small plant, a locomotive-type boiler with the fire- and ashpit doors entirely removed, the burner placed in the center of one or the other and aimed with geometrical precision at the center of the tube sheet. The burner itself, consisted of a piece of pipe flattened at one end to spread the blaze and the other end terminated in a tee, the oil line being connected to one side of the tee and the steam to the other.

In defense of such a primitive outfit, it may be said that like many other things which have come and gone, it served its purpose. It was easily applied and generated the required amount of steam at a much lower cost than would have been possible with any other fuel.

Incidentally, it may be said that right here is where oil burning got its "black eye," for people burning oil in this way or some other way equally reckless are the only ones that ever found oil burning "hard on the boiler." Whenever a man aims an oil burner at his tube sheet or boiler shell, he may as well make a standing contract with the boiler maker. Trouble is sure to come if the boiler is being fired up to its capacity.

Early Indifferent Design

Of course, no pretension is made that any such methods of oil burning are or were prevalent in the large stations. Yet it is true that little enough was done to insure economy in the furnace until the almost general adoption of oil as a fuel brought its price up until coal and lignite entered the field as lively competitors. Men who had been "cranks" on complete combustion when burning coal, stuck a burner or two under their boilers, put a torch to it, stepped outdoors to look at the stack to see that it was not smoking and then turned it over to the fireman. They were confident that it would work, but they did not care how much oil it burned, for oil was cheap.

The writer knows of one plant where a 250-hp. B. & W. boiler is fired with two burners in the ashpit aimed at a brick target. There is no way provided for regulating the draft, and while there is doubtless an excess of air admitted to the furnace, anyone familiar with oil burning could tell by the sound of the fire that the air is not properly mixed with the fuel.

Oil is no longer cheap, and in practically all plants of any importance the utmost care is being taken to secure the best results. Fourteen pounds of water evaporated per pound of oil burned is a result frequently obtained. Generally speaking, the principles of combustion apply to burning oil as well as anything else. The application of the burners, arrangement and dimensions of the furnace, etc., depend entirely upon the type of boiler. But, as intimated at the outset, great care in all cases must be exercised not to localize the intense heat on the surface of the boiler, regardless of the type. A sufficient amount of air properly admixed with the fuel while at the ignition temperature is all that is necessary to obtain complete combustion. To do this is not always an easy matter, and a method that will give excellent results with one type of boiler will fail utterly with another.

In one large plant there are five B. & W. boilers with which a saving of 11 per cent. was made by changing to the back-shot type of burner. A manufacturer of traction engines having the ordinary locomotive type of boiler, uses the back-shot burner, aiming the burner at a firebrick wall erected just in front of the fire-door, and claims that three barrels of oil do the work that it required four to do when the oil was introduced at the fire-door, and discharged toward the tube sheet. The writer equipped a return-tubular boiler with a back-shot furnace, assuring the owner that it would be a money saver, but the results were expensive and humiliating.

A Poor Arrangement

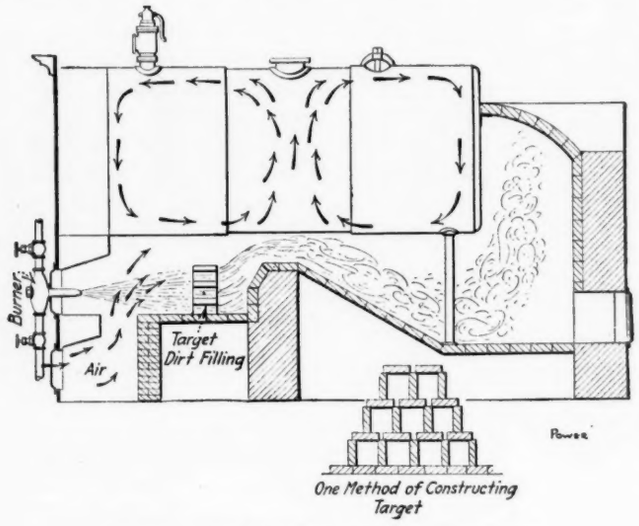
There is one method of applying an oil burner to a return-tubular boiler, which at one time was popular, but cannot be too strongly condemned, both because of its wastefulness and because it is productive of serious priming and expensive boiler repairs. The usual bridge-wall is constructed, the grate bars are omitted and the ashpit bricked up solid or filled in to the grate-bar level. Just inside the fire-doors, an opening the entire width of the furnace and 5 or 6 in. across allows air to pass upward from the ashpit doors. The burner is introduced through a hole between the fire-doors, and is usually directed against a target placed about two-thirds of the way between the boiler front and the bridge-wall. The accompanying sketch will make this clear. The errors and dangers of such a method are obvious. In the first place, it is impossible to obtain economical combustion. Cold air is admitted the entire width of the furnace and the first thing it strikes is the shell of the boiler, converting it into a condensing surface. A portion of this air will be drawn in and mingle with the blast of oil and steam issuing from the nozzle of the burner, but conditions do not at all favor a proper admixture of air and fuel. To obtain a sufficient amount of air to produce complete combustion, a large excess must be supplied, which, leaving the furnace at a high temperature, reduces the economy.

The second feature of this furnace to attract attention is the target. The object of the target is to spread the blast and cause the flame to fill the furnace, at the same time providing an incandescent surface to assist the combustion. Anyone who has ever used a target in this way knows how impossible it is to secure a uniform spreading of the flame in the furnace. Ever so much care may be exercised in erecting the target, and it may prove successful for a short time after the fire is lighted,

but the intense heat soon reduces the firebrick to the consistency of putty and they begin to gravitate in the direction of the least resistance. Inside of an hour or two the target looks like a piece of molasses candy on an August day, and the blast from the burner is directed perhaps against the sidewalls, which is bad enough, or against the shell of the boiler, which is much worse.

In the majority of cases where a target is used under a return-tubular boiler. It will be found that the blast of the burner impinges on a small area of the boiler shell at a point almost directly under the dome or steam pipe. The effect is twofold. First, it is dangerous and injurious to the boiler, and, second, it interferes materially with the steaming qualities.

No matter how clean the internal surfaces of a boiler may be, if the full force of an oil burner is directed against a small area of the shell it is certain that the heat will be imparted to the spot faster than the water will carry it away. I have been inside of boilers where I could tell exactly where the flame struck the shell by the discoloration of the plate. Besides the effect of such



EFFECT OF TARGET IN OIL BURNING

localized heat is to set up stresses in the plate that are apt to result in leakage at the girth seams, cracks and possibly an explosion.

On the other hand, it is evident that the water in the boiler will ascend from the hottest portion of the shell. Consequently if the hottest spot is directly under the dome, the water will rise most rapidly at this point instead of over the grates as it is supposed to do. There will be a double circulation. Rising in the middle it will divide, one current flowing toward the rear and the other toward the front. Each will turn downward and join again at the point of highest temperature, as indicated in the illustration. As this point is kept intensely hot, the ascent of the water and steam bubbles will be rapid, and bursting through the surface of the water they will be certain to carry some water into the dome or steam pipe. It is almost impossible for a boiler fired in this way to furnish dry steam. Engines taking steam from a boiler fired in this way have primed badly even on light load, but the priming disappeared when the method of firing was changed.

A target under a return-tubular boiler is always dangerous, but with the ordinary type of burner, if a target is not used, the first few square feet of heating surface at the front of the boiler will be of little use, for there will be little fire at the front. The heat will be farther back, and probably double-circulation will result.

There are two ways of successfully meeting these difficulties. One is by the use of a type of burner which spreads the fire at the front of the furnace without the use of a target. The other is by the use of a dutch oven; and in either case the air must be admitted below the fire and introduced in fine streams so as to use as little as will suffice to give complete combustion. There are a number of burners on the market, which give the spreading effect. In the plant of which I have charge, spreading burners are used. There are no bridge-wall nor grate bars. Two-inch scrap pipe is placed across the furnace, 8 or 10 in. below the usual grate-bar level, and supported on brickwork at the sides and middle. These are covered loosely with firebrick so spaced as to admit the proper amount of air and in fine streams beneath the fire. The fire floor is level from front to back. The flames have nothing in their path until they strike the protecting wall in front of the blowoff pipe. The burner is introduced through an orifice about 2 in. above the fire floor. With this method, a maximum of steaming capacity is obtained without any danger whatever of burning the boiler, there being no blast effect and no possibility of localizing the heat. Whatever type of burner is used, however, a dutch oven is a good investment.

MEXICAN OIL

The past year or two there has been a great deal of Mexican oil burned in this vicinity. When this oil is used, a target of any sort is out of the question, as a deposit rapidly accumulates upon it and has to be broken loose every 30 or 40 min., or it will deflect the blast from the burner against the boiler or some other point where it is not wanted. Mexican oil is heavy and of a jet-black color. Heating it is profitable in warm weather and necessary when it is cold. But this is accomplished practically without cost as the exhaust from the oil pumps is ample for the purpose.

It is advisable with any grade of oil, and especially with Mexican oil, to reduce the lift of the pumps as much as possible. If the elevation of the unloading track will permit, the storage tank should be placed above the level of the pumps and a suction pipe of ample size provided. Circumstances might justify elevating the tanks anyway, and the use of a pump to unload the cars.

In our plant the storage tank is located about 100 ft. from the pumps and about half above ground. If the tank is half full or more, the oil flows to the pump, and never has to be lifted more than 4 ft. Even then the pump does not have to lift cold oil. A 2-in. suction line runs from the bottom level of the tank to a small pit in the boiler room containing a heater made out of a piece of 6-in. pipe about 3 ft. long. This is capped at the ends and supplied with a few coils of 1-in. pipe through which the exhaust steam from the pump is passed. As the oil flows through the heater at a comparatively slow rate, it is warmed well up toward 100 deg. by the time it reaches the pump. This suction-line heater is called the secondary heater. A larger one in the discharge line from the pumps is called the primary heater. The exhaust passes through this one first and then to the secondary heater. The oil leaves the primary heater at

about 120 deg. This insures an even flow of thin oil to the burners. A relief valve is placed in the discharge line, allowing all surplus oil to flow back to the suction line. Both heaters should be bypassed so as to allow for repairs without interruption of the service.

When continuous service is imperative, everything, as far as possible, should be in duplicate. It is usually wise to even have two suction lines all the way from the storage tanks, and duplicate discharge lines to a point as close as possible to the burners.

Pieces of waste and other trash will find their way into the storage tanks and eventually get into the pump valves, burner valves or the burners themselves. It is well to provide a strainer of some sort to intercept these annoying bits of refuse, for it requires expeditious use of the monkey-wrench to change burners during a peak load without dropping the steam pressure.

As a rule, trash goes through the pump valves all right, and lodges in the burner valves or burners. Therefore, strainers are usually placed in the pipe line between the pumps and burners and are usually arranged so they can be cleaned by merely opening a drip valve at the bottom and turning steam on at the top; the oil having first been cut off. This is the work of but a moment and insures a clear line and good service.

To return to the subject of Mexican oil, it may be said that it is a great soot producer. If it is used, the boilers should be equipped with soot blowers, and these made use of every two hours. Besides being a soot producer, it is nasty and unpleasant to handle. However, its lower price justifies its use and it is also much less liable to explode in the furnace in case the fire goes out and then reignites, than are the lighter Texas oils.

Avoiding Furnace Explosions

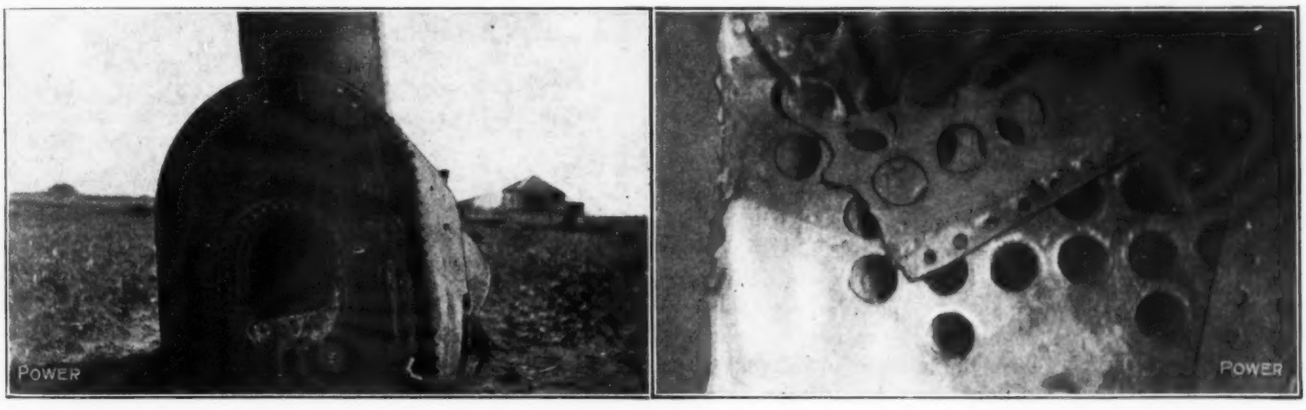
To avoid an explosion in lighting an oil fire, before applying the torch open the damper and ashpit doors and turn on the steam to clear the pipe and burner of water. When dry steam comes, shut off the steam and place a piece of burning waste a couple of feet in front of the burner; turn on the oil a little until it ignites, and afterward turn on the steam. In case the fire goes out, the steam should be immediately turned off; the oil will then ignite without explosion. But even in doing this the operator should guard his personal safety, as an explosion might occur just as he reaches the steam valve. Some engineers have placed doors in the side wall, opening upward, and consequently held shut by their own weight. If an explosion occurs, these doors open and relieve the pressure, thus saving the boiler walls. But it is obvious that if such an arrangement is resorted to, it should be carefully installed so as to prevent air leakage.

Unusual Features of a Boiler Explosion

Boiler explosions in general have a similar combination of conditions preceding them, but the results differ. In the case of the locomotive-type boiler of an oil-drilling rig, illustrated, the contributory causes were as follows: There was no glass gage. The fireman had other duties, and on returning he found only dry steam in the lower gage cock. He started the injector and returned to his other work. In a short time the boiler exploded. The somewhat unusual features are:

No one was injured.

There were no sheared rivets, the sheets tearing everywhere, except where the crown and flue sheets joined, where the rivets pulled out of both sheets



External View and View Inside of Firebox of Exploded Boiler

The stay-bolts in the crown-sheet, of which there are forty-two ¾-in., must have all pulled loose at once, letting it down evenly as it is flat (being flat to begin with); the edges are turned up, forming a rectangular tray.

Twelve of these crown-stays extended up to the top of the dome which was flat. These jerked the top of the dome down 2½ in. so suddenly as to break all the pipe connections, leaving the steam gage, safety valve and piping lying about the immediate vicinity.

The firebox was of the open-bottom type, and the force of the explosion hurled the boiler about 260 ft. sidewise instead of end over end.

Highest Power Locomotive—The most powerful locomotive unit yet built has recently been completed for the Erie Railroad by the Baldwin Locomotive Works. It develops a tractive force of 160,000 lb., accomplished by placing eight of the 24 63-in. driving wheels under the tender, making the weight of the latter available for adhesion. The locomotive is built after patents granted to George R. Henderson, consulting engineer, Baldwin Locomotive Works. The frames are vanadium steel castings of the unusual width of 6 in. The engine excels in efficiency for slow, heavy work, measured largely by the proportion of the total weight available for adhesion, 90 per cent. being in this case carried on the driving wheels as against 65 per cent. in a large Mallet. The total weight of the engine is 830,000 lb., of which 743,000 lb. is on all the driving wheels.

The Isolated Plant*

By W. A. Starkweather

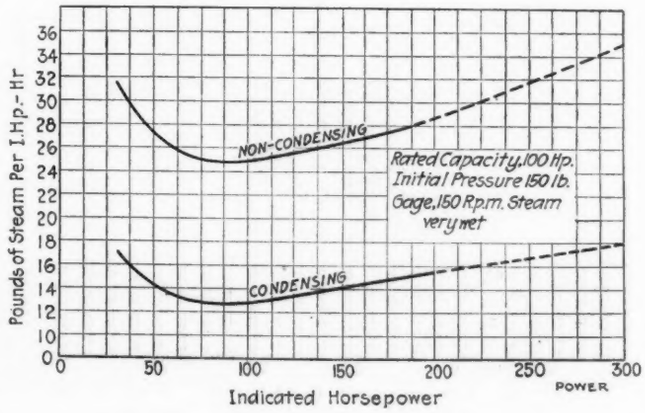
SYNOPSIS—A plea for more thorough systems of record and cost keeping in isolated power plants so that engineers may check the calculations of the central-station agents in times of proposed changes of the source of power. A plant has a cross-compound engine directly connected and operates in connection with a vacuum-heating system. The engine is operated continually on a compromise terminal pressure basis, depending on the outside temperature, but is always under more or less vacuum. The only heat loss is through the flue gases and condensing water.

The central stations in all large cities are of high capacities, run at high efficiencies and are usually operated by the most skilled men obtainable. Their entire business is the production of power at the lowest possible cost, and their efforts are united and concentrated to this end. They are assisted by a complete contracting and selling force of well organized men, keenly active and intent on securing all the business in sight. Moreover, their financial, political and social affiliations constitute a ramification of interest which frequently takes the problem out of the domain of engineering into one of convenience, policy or business management.

The two extremes of the central station are not debatable. There are some plants where purchased current is warranted and advisable. There are other plants where central current has no possible advantage. An example of the first would be a warehouse in which there is a small lighting load but occasional heavy elevator loads. This plant must be sufficiently large to carry the maximum load and be in commission and possibly in operation at a small fraction of its total capacity. An example of the second would be a dyehouse or bleachery, in which the load is steady and all exhaust steam is utilized. Conditions might be such that the plant could be a complete high-pressure turbine condensing installation, competing in every detail with the central station in low power-cost production. It is neither of these two extremes that are particularly interesting at this time, but the vast middle ground, constituting probably 95 per cent. of the plants where there is a combined load of power and light, several units in more or less good condition, where exhaust steam is utilized or where high-pressure steam is necessary for process work. There is no hard-and-fast rule for taking up these questions and arriving at a definite and final answer. No man can walk into such a plant and make a snap decision that will be anywhere nearly accurate. Each case, being peculiar in itself, requires special study. It is here that operating engineers usually lose ground. They may have the best intention; they may be careful, faithful and experienced, but if they are not actually prepared with reliable operating costs and such data, they cannot meet the central-station claims when the question arises as to whether the plant shall continue to furnish power or whether the power shall be purchased. Wild talk, prejudiced statements and harangues are utterly valueless.

*From a lecture before Providence, R. I., N. A. S. E. No. 1.

Taking an existing plant, one of the first things to determine is the load curve in horsepower- or kilowatt-hours per day for various seasons. If the load is fluctuating, this should be determined by a recording wattmeter or, at the least, by ammeter and voltmeter readings taken at regular intervals of 5 min. or so, for at least an hour, preferably as frequently and for as long a time as can be spared. Do engineers accurately know their daily kilowatt-hour loads? This brings us at once to the question of the proper size of unit to use for each load and requires the steam curve of the engine. Such a curve is shown in the accompanying figure. If electric elevators are on the system with their excessive starting load, it may be necessary to run several engines at light load to take care of the maximum, which may come on at any minute and require the ultimate capacity of all units, or



Performance Curves of Engine

one unit for the elevators, another for light, etc. These elevators vary in design and the power depends on weight, speed acceleration and drive. Generally 4 to 6 kw. are required per ton-mile, but this is only approximate. Variable-speed feed pumps are now built of such high efficiency that the old claim of enormous steam consumption for hydraulic elevators is not convincing.

The latent heat of exhaust steam, amounting to about 1000 B.t.u. per pound, carries an immense amount of energy which it will give up in the form of heat. A full-stroke elevator pump exhausting through a heater in which all the steam is condensed, the heat being imparted to the feed water, has a high thermal efficiency.

There should be means for weighing the coal and ashes and for measuring, at least by a meter, the water required by the boilers. These are the three fundamental measurements that should be made in any steam-power plant.

An employer should have no objection to telling the engineer the price paid for coal, and if the engineer has a method of testing various coals on a cost basis, he will be interested, for any intelligent owner is usually interested in dollars and cents. For instance, with coal at $4.50 per short ton and an evaporation of 10 lb. from and at 212 deg. F., the cost of 1000 lb. of steam is about 22½c. If one can obtain coal at, say, $3.50 per ton and get an evaporation of 8½ lb., the cost per 1000 lb. of

steam will be about 20½c., or a saving of nearly 10 per cent. This may mean handling an inferior coal and more ashes, and the use of such coal might possibly be limited by the capacity of the boilers, but changes might be made in the grates or in the draft which would secure better furnace and boiler efficiency. In general, the higher the furnace temperature up to the fusing point of the ash, the better. There is no apparent reason why the employer should not insist on buying coal on an evaporative basis with a penalty for nonfulfillment, but this requires an engineer who knows how and who will make a test.

An engineer should be prepared to urge the advice of a reputable consulting engineer whenever conditions are more than the engineer can handle. He will be helped more than hurt by this attitude.

The central station can produce current, so far as power-house costs are concerned, cheaper than the independent plants, and the reasons are obvious. There are the advantages of high load factor, low fuel costs, due to large contracts and bulk shipment; the handling of coal by mechanical means and the use of the most modern and efficient equipment throughout. Power-house costs are well below ½c. per kw.-hr. In railway power houses, the coal consumption is about 2 lb. per kw.-hr., everything included. Can engineers of isolated plants show records of less than 4 or even 5 lb.? When it comes to the distribution and utilization of the current, the losses in transmission and transformation amount to 25 or even 50 per cent., increasing the cost to the consumers to about ¾c. per kw.-hr. There must then be added to this net cost the overhead charges and other expenses of the central station, and these are often heavy, possibly bringing the charge for current up to, say, 1½c. per kw.-hr. Moreover, most central companies can only sell current at this price during certain periods of the day and for certain load characteristics and under certain forms of contract. I believe the majority of plants throughout New England pay more than 2c. net per kw.-hr. for purchased current. I am not now considering published schedules or the rates controlled by the state authorities, but the net costs known at several city plants. The question is, therefore, can the independent plant produce power for approximately 2c. per kw.-hr., or less, all charges included? No definite answer can be made which will hold in all cases, but, in general, this is possible.

The cost of coal is constantly increasing, while its evaporative power is possibly decreasing, due to poorer grades and higher ash content. The cost per thousand pounds of steam is, therefore, going up, all of which tends to increase the cost per kilowatt-hour.

Few plants utilize all of the exhaust steam either in winter or in summer, since the heating and lighting loads do not run parallel and exhaust steam is constantly being lost. The central plant does not operate this way, but every heat unit is caught. During cold weather, in the morning, the heating load at the plant may be equal to or even greater than the lighting load, but in the late afternoon the lighting load runs far above the heating load and, in general, is higher throughout the day, so that steam is constantly wasted to the atmosphere with all its latent heat not utilized. A recent high-class installation in a department store in Boston exhausts a great amount of steam throughout the day, even in the coldest weather, and it is a waste which in future will not be permitted. Even this plant is generating current for less than it can be purchased. Eventually, isolated plants will be run condensing in summer, fall and spring, even when natural-draft cooling towers on the roofs are necessary, and run noncondensing only when all the steam is needed for heating.

There is a plant in which the engineers have carefully worked out this problem and where no exhaust steam is wasted at any time of the year. The plant consists of a compound direct-connected condensing Corliss engine. The vacuum steam-heating system may be connected in with the condenser by means of a differential bypass valve which takes condensing water from the bay. There is a primary heater in the main exhaust and a secondary heater to take the exhaust from the pump. During the summer the engine exhausts directly to the condenser and full vacuum is used. As cold weather approaches, the steam is exhausted through the heating system and the vacuum is reduced to about 20 in. The steam still gives ample heat for two buildings which have many floors, totaling several acres. During the winter weather, the engine runs under a vacuum of only 10 or even 5 in., and on certain days, fortunately few, when the temperature is around zero and there are high winds, the engine operates at atmospheric back pressure; that is, the engine is operated continually on a compromise terminal pressure basis, depending on the outside temperature, but always under more or less vacuum. The only heat lost is through the flue gases and the condensing water. Lynn has a most efficient central-station service, but the plant referred to produces current and heat for far less than this station can supply it.

Marine Diesel-Engine Troubles

J. T. Milton in a recent paper before the Institution of Naval Architects gave a brief account of the performance of the Diesel-engine ships that have been built to date, only those troubles being mentioned that were attributable directly to the engines. In all, twenty-four vessels were mentioned, of which fifteen have reported troubles of more or less serious nature, the remaining nine apparently having, so far at least, a clean record.

Air-compressor troubles head the list, next to which comes cracked pistons due to faulty circulation of the cooling water as a result of scale or restricted passages. There were two of three cases of cracked cylinder heads and water jackets, due to the same cause; the scale deposits on the liners permitting them to become overheated, the expansion cracking the outer jackets. Two rather serious accidents were caused by bursting air receivers. In another instance there was trouble with the exhaust valves, and in still another the cast-steel cylinder covers were replaced with cast-iron ones.

One of the air-compressor accidents happened on the Swedish vessel "Suecia" when off the coast of Brazil. In this vessel the air is first compressed to 300 pounds by a two-stage air compressor, driven by an auxiliary Diesel engine, and is delivered to large receivers. At this pressure the air is used for starting, but for fuel injection it is taken from the receivers and further compressed to about 1000 pounds, at which it is cooled and stored in small receivers.

It was noticed during the voyage that an abnormal

quantity of lubricating oil was passing through the compressor and being blown out through the drains in the receivers. Also the cooler pipes, through which the air had to pass, had on several occasions become partly choked with greasy matter. They had been cleared by disconnecting and heating red hot, thus burning the grease, then blowing out the residue with compressed air.

An examination after the accident showed that an explosion had occurred first in the pipe leading from the air cooler to the high-pressure receiver, this pipe being burst in two places. The flame then passed the valve connecting the pipe to the receiver, melting a groove in it, and entered the receiver which in turn burst. The engine room was filled with smoke, which indicated combustion of oil and was evidence that the accident had not been due merely to overpressure as a result of pumping too much air into the receiver.

Another case of particular interest was cited. The "Christian X," on her third voyage to Baltimore, encountered heavy weather and was forced to slow down, during which time the fuel valves became damaged. As the oil used was easily ignitable, the valve setting suitable for running at full power with slower-burning oil gave too much lead when running slowly, and damage to the fuel valves resulted.

These troubles are such as might be expected in the application of a comparatively new type of prime mover into a field heretofore given up almost exclusively to another form of power. They should not be construed as necessarily detrimental to the progress of the Diesel engine in marine work as these problems will work themselves out in time, and it is only through such troubles that perfection is approachable.

Engine-Speed Variation

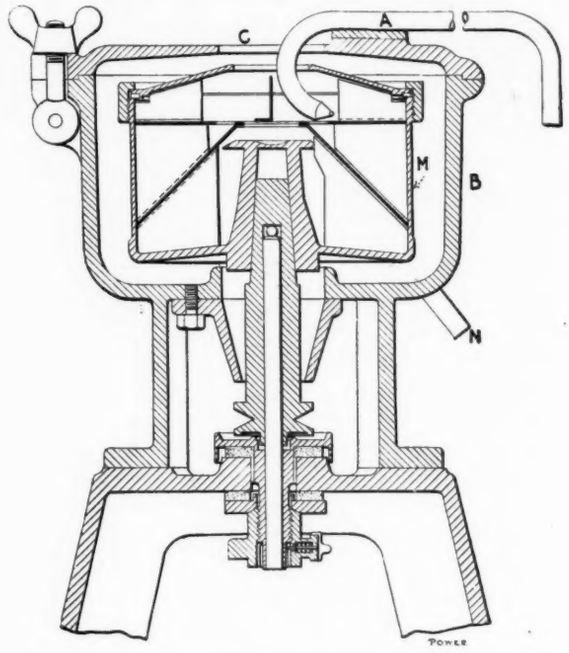
The speed variation of an engine that drives a single generator is not ordinarily a source of trouble, because under such circumstances it is the practice to keep the voltage normal by adjusting the field rheostat. Where compound-wound generators operate in parallel but are driven from different engines, one of which governs much more sluggishly than the other, equalization of the total load between the two is apt to be affected temporarily, and where the speed decrease, due to load, is a greater percentage of normal speed on one engine than on the other, equalization will be permanently affected.

An inspector was called to find out why two generators failed to divide the load proportionally within guarantees at all loads. Compounding curves were run on both machines and, roughly plotted as they were, they compared deceivably well with each other and speed variation was not suggested; but on comparing the curves with the original compounding curves run at the factory one of them was found to be much flatter than it should have been. At this juncture, the operating engineer imparted the welcome tip that he did not think that the speed held up on one engine as well as it did on the other; a test proved this to be true. The total variation on one from no load to full load was about 3 per cent. and that of the other exceeded 7 per cent. but was easily improved, after which equalization was satisfactory at all loads. In other cases, however, a difference in the percentage speed variations of two engines has actually improved the equalizing characteristics.

Atom Centrifugal Oil Purifier

This machine, by centrifugal force, separates impurities from thick or thin oil, also water from oil.

The purifier has a cylinder *M* which contains the necessary filtering surface for removing the coarser particles in the oil to be purified. The clean oil then runs out of the pipe *A* at the top of the machine, the foreign matter



Section through Centrifugal Oil Purifier

being discharged from the casing *B* through the pipe *N*.

The inner cylinder is revolved at 5000 r.p.m. and a pressure of 118 lb. on the oil is created during the operation. Dirty oil is fed in through the top *C* of the purifier from a small tank into which the oil is returned after being used in the engines, pumps, etc.

This purifier is made by N. A. Sansteby, 213 Lloyd St., Grass Valley, Calif.

Frictionless Bronze-Bearing Tests

Tests have recently been conducted by the American Metal Co., Pittsburgh, Penn., to determine the efficiency of a bronze journal bearing composed of 65 per cent. copper, 30 per cent. lead and 5 per cent. tin, treated in crucibles; they are solid-bronze castings requiring no babbitt surface.

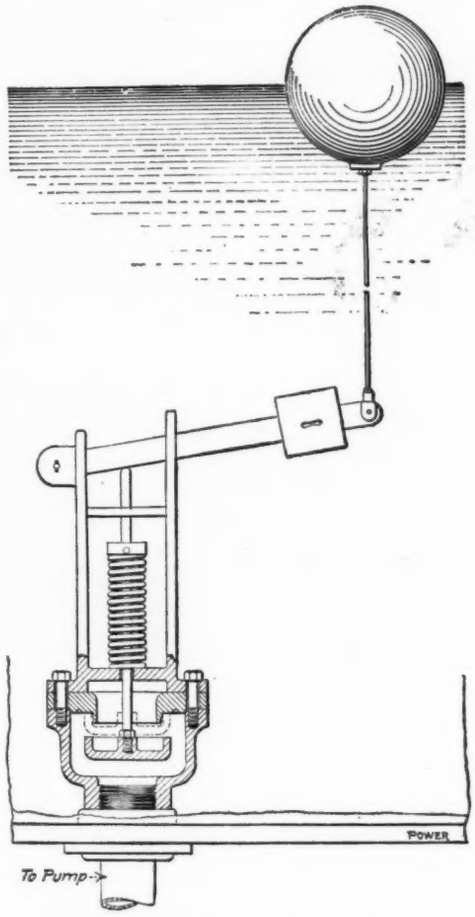
In one test a 22-lb. bearing was placed under the tender of a Pacific-type locomotive. After the engine had run 51,000 miles, the bearing showed that it had worn $\frac{1}{32}$ of an inch without becoming heated at any time. Other bearings on the tender were rebabbitted six times each during the same run.

A test was made at the Soho works of the Jones & Laughlin Steel Co., Pittsburgh, where two 75-lb. mill brasses were used under the rolling table of an 108-in. plate mill, the minimum weight of which is estimated at 10,000 lb. The superintendent of the mill stated that the two brasses gave continuous service for four weeks, or twice as long as the ordinary phosphorus-bronze bear-

ing. On account of the position of the bearing, it was impossible to lubricate the brasses during the test, other than by the graphite in the lead.

Fisher Check and Float Tank Valve

The valve shown herewith has been designed for the automatic control of water levels in open or elevated tanks or gravity systems. It is installed at the bottom of the tank and its construction permits water being pumped into or drawn from the tank through the same pipe. In operation, it combines the features of a float and check valve, and in closing it tends to cushion itself, so that the movement is slow enough to obviate water-hammer and the sudden stopping of the pump.



CHECK AND FLOAT TANK VALVE

The spring tends to seat the valve against the downward thrust of the weighted lever, and the pressure in the pipe line opposes the head of water in the tank. When the water has reached the desired level, pulling the float with it and raising the lever, the spring seats the valve. Back pressure immediately builds up in the pipe line sufficiently to stop the pump through the action of the pump governor.

Water may be drawn from the tank through the same pipe. As soon as the pressure is relieved the pump starts, supplying the demand until consumption is stopped and then refilling the tank to the desired level. When the tank is full, fire pressure may be carried on the mains with no danger of overflowing the tank, as the pressure in the pipe line tends to close the valve. The Fisher Governor Co., Marshalltown, Iowa, has recently added this device to its power-plant specialties.

When Horse Sense and Horse Power Were Lacking

The engineer of this narrative, whom we will call Reuben, had before him the task of moving a 5x16-ft. horizontal-tubular boiler from a flat-car in the railroad yard to the plant. Reuben was poorly paid—in a word, he was a "cheap" man.

The opening exercises consisted in getting a wagon, that was wholly inadequate for the purpose intended, parallel with the flat car. The wheels were blocked fore and aft, and the horses detached and swung around to take a rolling hitch on the boiler to roll it from the car to the wagon.

Here Reuben's lack of mechanical knowledge asserted itself in a somewhat amusing way. An ordinary flat car stands about 3½ feet above the surface level, and the five-foot boiler on the car made the chain hitch about 8½ feet above the ground level. The team hitch was made of such length that the line of pull was at something like 45 degrees.

After two or three unsuccessful attempts, Reuben saw the point and lengthened out the hitch to avoid lifting the team off the ground. The boiler was then rolled on the wagon and its movement toward the power station started. It was soon stalled, however, beyond all efforts of gods, men and horses at a point where the wagon way crossed the private side track to the power station. This "plugged" the switching service, so that coal could not be delivered if Reuben did not get out of the way with his "biler" and wagon. It was a common dirt road and in its worst condition at that.

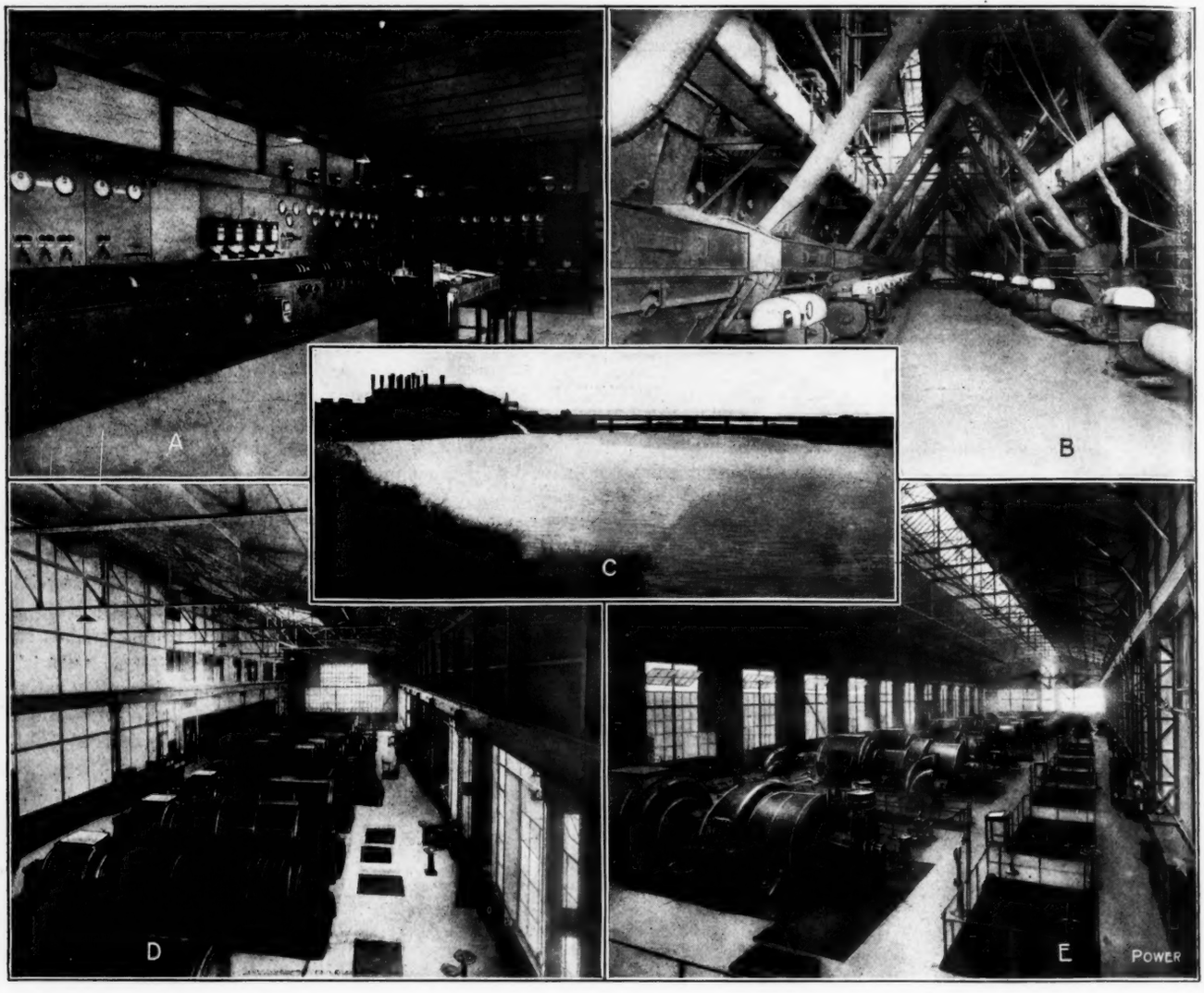
On the highway a steam road roller was at work, and it was suggested that perhaps he could negotiate for its use; it might answer as a traction engine.

The outcome was successful. The steam roller had all that it could do, and its big flat drivers went around and around without making much material progress. Then one of the wagon wheels began to exhibit symptoms of collapse, and a man with a pail of water was delegated to keep the hub well wet down to hold the wheel together if possible to the journey's end. The quarter mile to the power station was traversed in about six hours. Notwithstanding the many exciting events on the way, the wagon and its burden arrived right side up.

This shows that it is not merely time and energy that are wasted when work is done by men who have no idea of what method is. There is a considerable risk attending the careless handling of heavy apparatus, but it does not seem to appeal to the employer who hires only men who will work for small money; "cheap" men.

Incompetence in or about a power station should not be tolerated. An engineer should be able to reason quickly and logically. In case of emergency, he should be able to rise to the occasion and render good service. When employers learn the meaning of the term efficiency as applied to men as they now understand the term when it is applied to apparatus, there will be a decided improvement in the ranks of the engineering profession.

South African Power Plants



VIEWS OF POWER-PLANT INSTALLATIONS IN SOUTH AFRICA

A. The switchboard at the Rocherville power station, Victoria Falls Power Co., Ltd. B. Rocherville power station boiler house, automatic stokers feeding small nut coal. C. View of Vereeniging station of the Victoria Falls Power Co., 90 miles from Johannesburg on the Vaal River. D. View of the Robinson central station of the Victoria Falls Power Co. The nearer machines are 4000-hp. rotating air compressors with the cover removed to show the cooling arrangement of the water-tube jackets. E. Engine room at the Rocherville station, Victoria Falls Power Co., showing the 5000-hp. rotary generators with air compressors at the far end.

The Victoria Falls & Transvaal Power Co., Ltd., was organized in 1906 to supply power for South Africa and Rhodesia and acquire the concessional rights to develop the Victoria Falls. In 1908 the group of mines controlled by the Rand Mines, Ltd., and Eckstein & Co. changed over to electric drive and, in addition, compressed air was required. This led to the formation of the Rand Mines Power Supply Co., and, although these companies are working under separate license, they are practically one organization.

The peak load of the combined undertaking has reached 88,000 kw. The power supplied is at 2100 and 525 volts. The necessary step-down transformers, etc., are provided by the power company, the consumer supplying the substation building and paying the power company a sum equal to 2 per cent. of the power bills to cover the losses in the transformers. The area supplied is confined within a strip about two miles broad and 50 miles long, running east and west through the mining district.

At all the stations steam turbines and alternating generators are used, producing 50-cycle, three-phase current; step-up transformers raising the pressure to 10,000, 20,000 and 40,000 volts. The main transmission system involves 40,000 volts overhead lines, and where the load is most dense, the system has two rows of towers, each being arranged to carry two circuits.

There are two central air-compressing plants serving the mines, and are built about 14 miles apart; the total length of the pipe line is about 20 miles, varying from 9 to 24 in. in size. The rotary compressors are rated at about 3500 kw. each and are said to be the largest yet constructed. The delivery pressure of the air has to be about 100 lb., the average drop from the compressors to the consumer being not over 6 lb. There are 4000 joints designed to allow for contraction and expansion of the pipe lines.

Editorials

Water Rights

The Constitution of California declares that water appropriated for sale is appropriated to a public use. By statute the County Boards of Supervisors are authorized to fix rates so that the returns to the companies furnishing the water shall not be less than 6 per cent. upon the value of the canal, ditches, flumes, chutes, and all other property actually used and useful to the appropriation and furnishing of such water.

Some of the companies, not content with a profit of not less than 6 per cent. on the money actually invested, claimed that they were entitled to an equal percentage upon the value of their water rights, and the Supreme Court has just issued a decision upholding that contention. As this decision will apply to water rights granted for power purposes, it will be of wide effect, and should stiffen the conditions under which such water rights are surrendered to private or corporate control.

The Reading Habit

Commenting on getting the habit of reading, the *Saturday Evening Post* says: "Hardly any other habit will stand a young man in better stead than a reading habit, both for what it includes and what it excludes. Of all habits it is the pleasantest, the cheapest and the most dependable. You can indulge it regardless of weather, seasons and location. For almost any intelligent young man it is an easy habit to form. That and a habit of physical exercise will make nearly any man fireproof against chronic dissipation."

If all this may be said of a habit of general reading, now much more might be added for a habit of reading along the lines of one's work—reading that is akin to, if not quite, studying. The first, a general reading habit, may be "the pleasantest, the cheapest and the most dependable." The habit of selected reading or studying is all of that and more—it is the most profitable.

By general reading one may acquire culture, may make himself so well informed on miscellaneous topics, that he is a delightful conversationalist and an agreeable companion. On the side of the things excluded, he may avoid habits that are extravagant, and even positively injurious. Again we say, he may equally do so with reading to improve his knowledge of his calling, and all those traits that make him companionable to his fellows interested in the same field of effort will be incidentally developed.

General reading of a proper kind is elevating and does make the reader a better man, but technical reading makes him a better engineer. Entirely apart from the reward of a more responsible position at a higher salary as a consequence of greater knowledge, technical reading pays when it brings a man a better understanding of all that pertains to the place he is now filling, when it enables him to take part intelligently in discussions on engineering subjects. The respect of others and his self-respect both increase.

The other habit recommended in the quotation, physical exercise, needs no endorsement to engineers. They automatically get plenty of exercise—or most of them do. So we would concentrate on the plea for the reading habit even if we do appear to be actuated by a motive of self-interest. To be sure, if the reading habit became extinct there would be little use for either papers or editors. Our service can never avail much if what we print is not read. "You can lead a horse to water, but you can't make him drink." We can scour the field and corral in these pages what we believe it is for the readers' good to know. That is as far as we can go. You must take the receiver off the hook to get our message over the telephone; you must take off the wrapper and open the paper to get our message through POWER. The same is true of those books on your shelf and any other literature you neglect.

P. S.—Since we wrote the above, it has dawned on us that those who will read this editorial do not need it and those who need it will not read it. Then what did we write it for? Perhaps it was in the hope that those who read it will show it to those who need it. Will you?

Vocational Training

In a short time, thousands of boys and young men will have been graduated from the grammar and the high schools, the great majority of whom will have to seek work at once. How many have been fitted by what they have learned for any kind of work? How many know what they really want to do?

There are a few cities in which the "continuation-school" method is in vogue, and it has proved its practicability. By this method, the young employee is allowed time during his working hours to pursue those studies which will ground him in his chosen vocation, will create a desire of understanding what he is doing, why he is doing it and will show him that his advancement greatly depends upon a sound knowledge of his work.

While we look to the boards of education for the installation of the continuation school, its adoption mostly depends upon the interest taken by the employers and the public, as it will be supported by them jointly.

But, says Arthur D. Call, a well known educator, the boy must be studied as well as the vocation if the schools and the workshop are to properly dovetail. We quote:

> The one outstanding lack in our American education is the general failure to take into consideration the personal equation. Pupils are educated in a haphazard way, with no effort to determine in which direction their talents may lie.
>
> Their qualifications now can be determined with scientific exactness. Educators generally fail to recognize even the broad and easily determined facts about a child. For instance, it is generally known that there are two great classes of children, the object-minded and the idea-minded. One class thinks in objective terms, the other class thinks in words.

The Census Bureau states that but four per cent. of our people are in professional service, sixteen per cent. follow the trades, thirty-six per cent. are farmers, and twenty-four per cent. are manufacturers. These figures show roughly that the present school system is training over eighty per cent. of the pupils for about four per cent. of the opportunities. This is a most convincing argument that the schools are not doing the greatest good to the greatest number.

To provide vocational training, one state alone spends $50,000 a year on 250 children in its trade-school work. Wisconsin has 25,000 in its "continuation" schools, and, owing to their popularity, this state will have about 40,000 scholars next year. If the continuation-school idea were more generally understood, it would undoubtedly be more widely adopted.

The conditions under which many operating engineers now labor for the education denied them as boys, should prompt them to help devise ways whereby the young helpers in the plant can arrange with their employer to get time off to study. It can be done in many plants, and it is up to the engineer of today to interest his employer in this matter and find the means to make it possible for the engineer of the future to properly equip himself for his vocation.

Distilled Makeup Water

The amount above normal rating at which a well designed boiler may be safely operated depends chiefly upon the scale-forming solids and the suspended matter in the feed water. In his paper treating of the operation of the large boilers in the Delray station of the Detroit Edison Co., and read before the American Society of Mechanical Engineers at its December meeting, J. W. Parker stated that one-sixteenth inch of scale on the hot front tubes caused overheating at high ratings. It was brought out in the discussion of Mr. Parker's paper that scale of eggshell thickness and covered with mud, in tubes of a boiler driven at moderate ratings, caused serious overheating. In this latter case the feed water was taken from the Alleghany River and contained from six to ten parts per hundred thousand of incrustating solids.

In large central stations or other steam-power plants where modern practice dictates that the ratio of installed prime mover capacity to boiler capacity shall be high to minimize investment and overhead charges, the reliability of the boilers must of necessity be high, especially in plants where the units are very large, as at Delray.

In the hope of increasing the reliability factor of the large boilers under his charge, Mr. Parker stated in his paper that he seriously contemplated using distilled makeup water, believing that there is a lack of evidence that distilled water is of itself corrosive. To safeguard against against possible corrosion, however, it is intended to feed in with the water enough soft-scale-forming material to cover the heating surfaces with a thin protecting scale. In his recent talk before the Engineers Club of Boston, Captain Manning said of the scaling of boiler tubes:

". . . but the correct solution is to use water that makes no scale, purifying the water before it is fed to the boilers."

In the discussion that followed Captain Manning's talk, James D. Andrews, of the Edison Illuminating Co., of Boston, agreed that evaporators for distilling makeup water should be provided. We understand that H. G. Stott, of the Interborough Rapid Transit Co., is considering the use of distilled makeup water for the remodeled Seventy-fourth St. plant, where the boilers will be driven at four hundred and fifty per cent. rating at times and three hundred per cent. regularly on the morning and evening peaks.

All this activity shows the trend in boiler practice in large plants. Whether distilled makeup water will be advantageous or disadvantageous in such plants, remains to be proved by the results of its use in some of the plants now contemplating it.

The first thought that comes to one considering it is that it has been used in marine practice for years without giving really serious trouble. The cost of distilling makeup water is not an important consideration, for, even in extreme cases, the quantity of water will not exceed fifteen per cent. of the total and, in well conducted plants, where leakage is closely watched and minimized, it will be as low as five per cent.

After nearly a year from the time the engineers' license-law bill passed the New Jersey legislature, that body has appropriated a sum to put the license bureau in operation. A state-wide license was a mighty long time coming in Jersey, and because of this and the industrial importance of that state there is all the more reason for rejoicing. The Commissioner of Labor under whom this work will be done requests that engineers do not write for applications until the license bureau is organized, which fact will be announced at the proper time.

The "how" and the "why" should more largely govern our contributors and correspondents when writing for the paper. Complaint is made occasionally that the "blue pencil" has, in the words of a recent writer, "sadly mutilated" an article or letter. It is clearly impossible for POWER to publish all our contributors would write. The best and most highly trained writers stop when they have said their say. We hope that some of our writers will strive to imitate them. Be brief, and to the point, and you will better interest the readers, and make your contributions all the more acceptable.

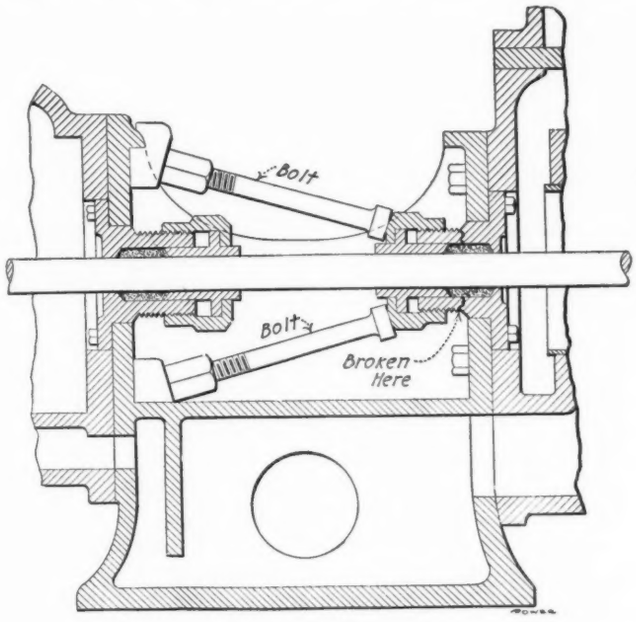
Our Sunday supplement writers would do well to consider the power plant as a peg on which to hang a good "human-interest" story. Handled skillfully and understandingly, it would appeal strongly to the lay reader, and incidentally give him a knowledge of the power-plant engineer's responsibility and of the public's great dependence upon him for its many necessities and its safety.

The smoke-abatement movement in England is making but slow progress, chiefly owing to the inability of its advocates to introduce a bill into Parliament this year. At times, we fret because of the "red tape" of our state legislatures, but we are not further hindered by the "private bill"—meaning a bill not proposed as a government measure. As gas is cheaper than coal, notably in London and in many provincial towns, the apparent indifference of Parliament to the abatement of smoke may be thus explained. The advocates of such a bill are hopeful, however, and intend making another effort next year.

Correspondence

Temporary Pump Repairs

The stuffing-box on the steam end of a pump was broken by frost as shown. The pump was made serviceable (and operated for 10 days until a new part was received) by inserting $\frac{1}{32}$-in. sheet packing, coated with



Bolts in Position

shellac on both sides, between the broken parts. Pressure was applied by means of two bolts and nuts fitting snugly, then backing out the nuts a few turns.

Fred W. Schneider.

Clay Center, Ohio.

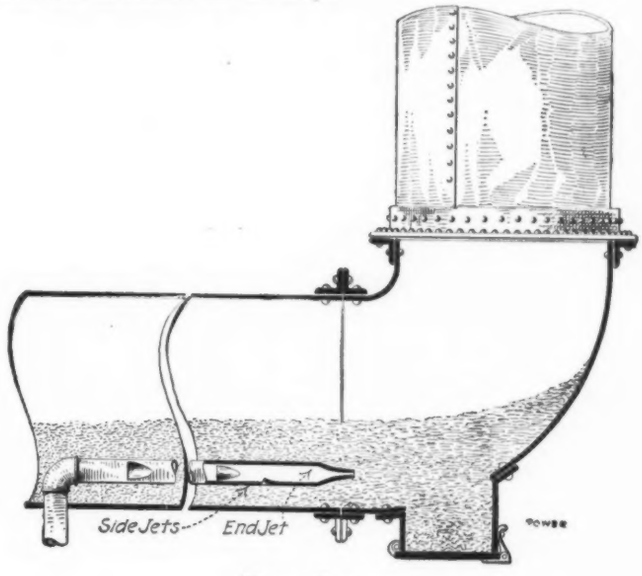
A Flue Cleaner

A certain plant had two 54-in. return-tubular boilers. The 40-ft. horizontal flue, 30 in. in diameter, was connected directly to the bottom of the 32-in. stack without any settling chamber for the soot. We had difficulty in keeping it clear enough to insure a good draft, especially in winter.

The usual method had been to clean the elbow through a small hole in the bottom every few weeks and once or twice a year have the whole crew spend a Sunday cleaning out the entire flue. This was a very disagreeable job for the men, besides depriving them of their Sunday; moreover, our draft was constantly changing. After participating in this event several times, I did the work with a blower.

I cut a piece of 1¼-in. pipe long enough to reach from the front of the flue back to the damper. Then I heated and flattened one end until it formed a $\frac{1}{16}$-in. nozzle about 2 in. wide. Every 4 ft. of its length I made jets, as shown, in groups of three, one on each side and one on the bottom, staggering them so as not to weaken the pipe. To make the jets, I first sawed into the pipe to the depth of a hacksaw blade, then hammered down the front side, forming a jet to throw the steam at about 30 deg. with the pipe. In action the steam jet would dig the soot off the walls of the flue and carry it toward the stack and out of the hole in the elbow. I put a second section between the damper and the stack, arranging valves so that they could be blown independently.

When the blower was installed the soot was nearly a foot deep in the flue as I had allowed it to accumulate as a test. With the plant in operation, two men cleaned the flue thoroughly in less than an hour, using steam at 70 lb. We always have the damper open. By opening a smoke-box door, we could get draft enough to carry the soot out of the top of the stack, but, of course, that was not advisable in the city.



Flue Cleaner

This outfit was made of old stock and the work was done by the regular force so that the cost was practically nothing. The improved combustion and the ease of cleaning were greatly appreciated by all concerned.

H. K. Wilson.

New Bedford, Mass.

Points on Babbitting

Mr. Allen's article on page 487, April 7, 1914, should be of great service to many. That a well balanced, lead-based metal will meet all ordinary cases is not generally known, but in many cases, it will give far better results than expensive babbitt.

Salesmen are always calling one's attention to the low coefficient of friction of their wares, but is not this point under running conditions (as the shaft should not be touching the metal) governed by the lubricant?

As to pouring bearings, I prefer to use either soap or

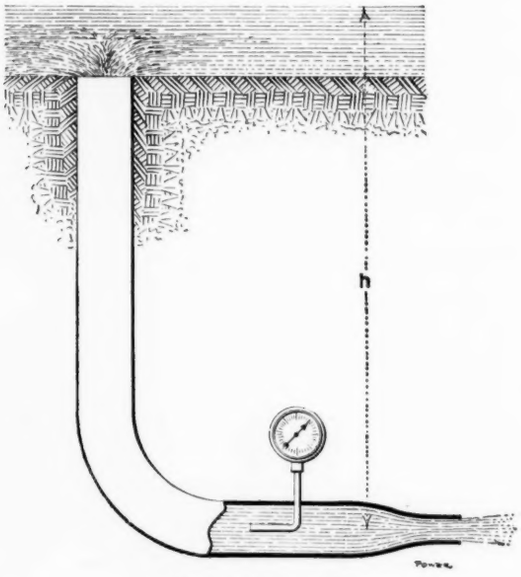
asbestos, in the form of a heavy sheet or square rope, to clay, as there is less chance of a boil through moisture. In bearings to be run in quickly and got back into service, I use a piece of thin tracing paper fastened around the shaft by strong threads, letting the ends overlap by about $\frac{1}{16}$ in. This is then well rubbed with powdered graphite after strips of asbestos have been fastened on for oilways. The shaft is lined up and the housing warmed with a blow torch. Just before pouring, a little powdered rosin sprinkled into the gate will ensure a sound casting. As soon as the metal is set the paper and asbestos strips are scraped away and the bearing surface is well oiled and liberally sprinkled with graphite. In three out of four cases, it will not heat from the start.

E. R. Pearce.

Rochdale, England.

Small Water Motors

With a view to assist those interested in such problems, the writer offers a few simple rules of hydro-power development on a small scale, which also apply to the largest developments.



Gage Attached

The foot-pounds of energy in water is equal to the weight of the water multiplied by the distance in feet through which it falls, or pounds weight multiplied by feet fall equals foot-pounds, which divided by 33,000 equals the gross or total horsepower. This, however, is never realized in practice, on account of various losses. The average mechanical efficiency of waterwheels is about 75 per cent.

To ascertain the power in a small jet of water, place a pressure gage in the pipe immediately behind the jet, as shown in the illustration, and while discharging observe the pressure in pounds per square inch. This will be the effective pressure; that is, the total pressure due to the head minus the loss in overcoming pipe friction.

Multiply the effective pressure by 2.3, which will give the effective head in feet. Collect and ascertain the weight of water from the jet in one minute. If measured in gallons, multiply the number of gallons by 8.34 (the weight of 1 gal.), which will give the total weight in pounds.

Multiply the weight of water in pounds discharged in 1 min. by the effective head in feet as ascertained above and divide the product by 33,000; the quotient will be the horsepower that the jet delivers to the wheel. Multiply this last quantity by 0.75, which is a fair degree of efficiency for a small water motor, and this final product will be the useful horsepower.

It should be noted that the larger the jet used for a given sized pipe, the less the effective pressure will be and even if a larger final product is obtained, it will be with great extravagance in the use of water.

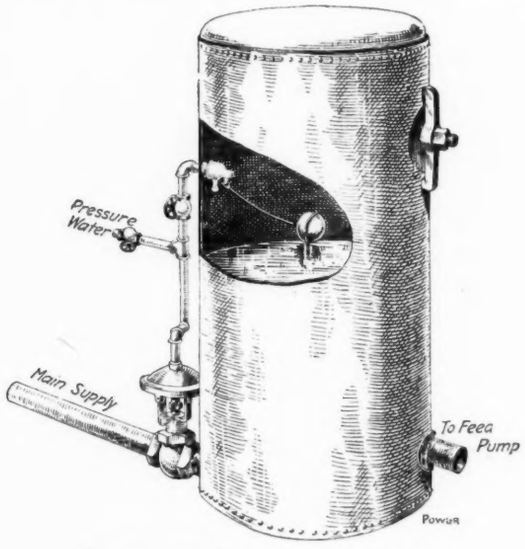
T. H. Reardon.

Pittsfield, Mass.

Water Control for Tanks or Heaters

The illustration shows a semi-home-made water control, which is capable of numerous modifications. The principle is that of the boiler-feed regulator. In this instance the float, or pilot, valve was an ordinary closet ball cock. The pilot, being of the smallest size, does not require a large float and therefore is not likely to collapse.

The tank was drilled at about the maximum level for the water; then the pilot valve inserted therein, and connected to the pressure water main by a $\frac{3}{8}$-in. pipe, one branch of which was connected to the bonnet of a 4-in. diaphragm valve on the main return line. In action, when the water in the tank raises the float, and the pilot valve closes, the water pressure will then close the diaphragm valve on the main supply. If it is desired to close the diaphragm valve for any purpose without regard to the water level, it may be done by closing the



Pilot and Diaphragm Valves

upper globe valve. Likewise, if this valve is to be held open, that on the pressure water may be closed and the pressure released from the diaphragm.

When two sources of supply to a tank, such as heating system returns and makeup water are to be regulated, the makeup pilot valve should be located at the minimum level and the other at the maximum. A better form of construction, with the advantage of having all parts

exterior to the tank, can be made by using a boiler feeder of the type used on cast-iron heating boilers or, still better, a regular high-pressure boiler-feed regulator for the pilot.

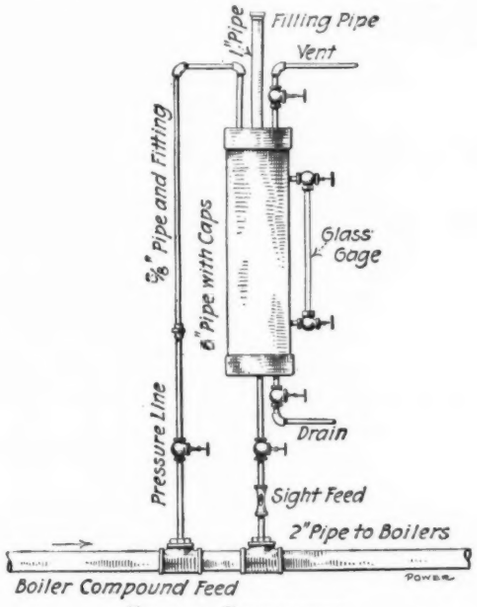
All of the parts entering into this construction are standard and procurable at supply houses. It is, therefore, not a makeshift or an apology for something else.

LEON LEWIS.

New York City.

Boiler-Compound Feeder

A boiler-compound feeder to be connected to the discharge line of the feed pump is shown in the illustration. It should be set above the feed line to get enough



FEEDER CONNECTED

static head, which, plus the pump pressure will be sufficient to discharge the contents. Perhaps this is not a new idea, but it may be of value to someone.

C. T. BAKER.

Jacksonville, Fla.

Auxiliary Economy in Steam Power Plants

The article on the auxiliary economy in steam-power plants, on page 436, Mar. 31 issue, is timely. We have consistently fought for high economy in auxiliary apparatus, both as to high-vacuum and low-steam consumption. The editorial on page 452 is also appreciated. The following is the substance of a letter on feed-water heaters which we are sending to consulting engineers. There are many engineers who will not have an open heater because of oily water, and while this objection is disappearing with turbine-driven auxiliaries, this only applies to large plants.

The letter reads as follows:

As manufacturers of feed-water heaters of the closed type, we wish to call the attention of consulting engineers to the question of rating, or the amount of surface offered by various bidders to secure specified results with given conditions. The situation has been going from bad to worse in the past few years and the present confusion is not creditable. Heaters are rarely tested to determine satisfaction of guarantees, so that misleadng statements continue unchecked.

On a horsepower basis, the surface is stated as low as 0.2 of a square foot, and as high as 0.5, the smaller amounts being claimed sufficient because of improved transmission rates due to increased water velocity (on which there is no patent), better conductivity (although with practically the same metal in all), molecular movement, stream lines, etc. While there may be a slight difference with various designs, we contend that this is not enough to warrant 250 per cent variation in surface, on which cost primarily rests. We estimate the surface as follows:

W = Pounds of water per hour;
K = The constant of transmission, 250;
T = Temperature of steam;
t_1 = Temperature of entering water;
t_2 = Temperature of departing water.

The formula is:

$$S = \frac{W}{K} \log \frac{T - t_1}{T - t_2}$$

The results from this formula confirm experience, that an approximation to within 5 or 7 degrees of the steam temperature can be reached with commercially reasonable surface, and that this is practically all that is usually obtained in any event. There is not enough final temperature difference between steam and departing water to warrant the necessary excessive surface to work to within 2 or 3 degrees of the steam. A recent case required 30 square feet for 7 degrees and 3500 square feet for 2 degrees approach to the steam temperature.

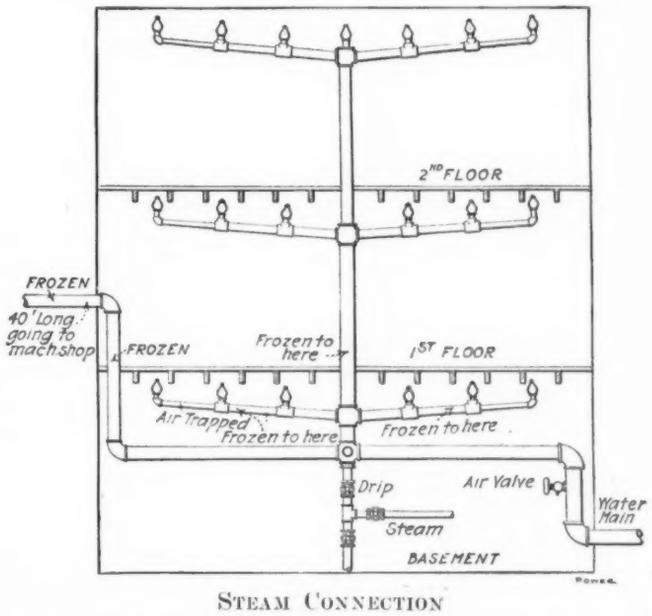
This same problem has been developed in surface condensers, where heat transfer depends largely on the same elements as in closed feed-water heaters, and a safe and sane basis has been reached. We are therefore suggesting that it is well within the province of consulting engineers to specify the minimum surface allowed, with the corresponding guarantees which manufacturers will make for a given set of conditions. This is a usual procedure in surface condenser tenders, and we respectfully urge you to apply it to feed-water heaters. It will standardize practice and insure better sustained results.

W. G. STARKWEATHER,
C. H. WHEELER MFG. CO.

Boston, Mass.

Care of Sprinkler Systems

During extremely cold weather a sprinkler system, if called into use on account of fire or testing, may become frozen at exposed points before it can be drained and refilled with air. This, of course, applies to the "dry pipe" system in which the air excludes the water until allowed to escape by the action of the heat on the "automatics"



STEAM CONNECTION

in case of fire. I have found a steam connection with a drain at the lowest point the most convenient means of thawing it out. The points of caution are not to use

more than 5 lb. of steam pressure, and that, for short intervals, and to drain frequently to avoid water-hammer. The condensation will be rapid and the melting ice will increase the amount of water.

When the system is cleared and again filled with air, allow it to stand for an hour before turning on the water valve in order to test for leaks. If the pressure drops it is a sure sign of leakage.

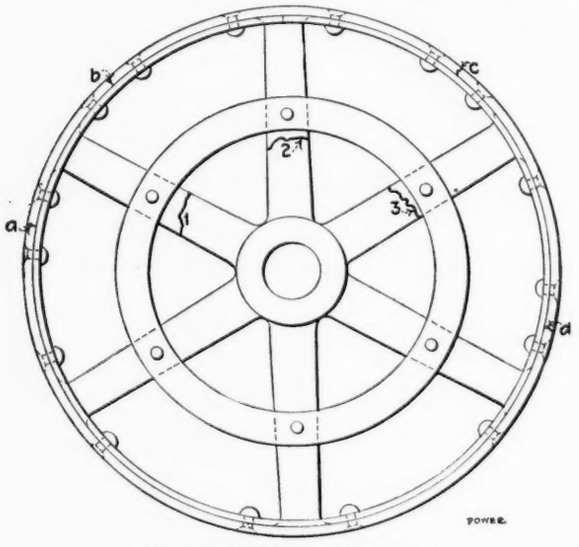
I find a small amount of ether or oil of peppermint in the system helps to locate small leaks which cannot be detected by sound or otherwise.

HAROLD BURRILL.

Middleville, N. Y.

Emergency Repairs

A 16x14-in. cast-iron driving pulley for a forced-draft blower broke in four places on the rim at the points *a, b, c* and *d* in the sketch. Three of the spokes were also broken off at the points 1, 2 and 3. Repairs were made



BROKEN WHEEL REPAIRED

in 10 hr. by making two rings of ½x2-in. flat steel and riveting one ring on each side of the spokes with ⅝-in. rivets. The rings were heated slightly, then riveted in place quickly. When cold, the contraction drew the broken spokes together securely. We then riveted a flat sheet-iron ring $\frac{3}{16}$x6 in. on each side of the spokes with ¼-in. rivets, which completed the job.

S. E. RAYMOND.

Trenton, N. J.

Why the Brine Temperature Was High

When I was hired as assistant engineer on the night shift, I told the chief that I knew nothing about an ice machine. He said he would show me how to operate it and I would soon learn, so I went to work. His instructions were about as follows:

"When that pressure gage (pointing to one of several on a board) goes over a certain limit, close this valve a little; when the pressure drops, open it again; when the liquor in that gage-glass goes up or down from a string tied around the glass), either start up the pump a little or slow it down. That is all you will have to do, and if you let the rest of the system alone, you will not have any trouble."

Excellent instructions, but as the other assistant slept in the house and I could call him if necessary, I accepted the situation and made no comment. However, everything went all right, and there was no trouble that night, but the next morning I went after the other assistant for some information about the ice machine. He willingly answered every question, and in a few days I had learned a little more. We went along all right for a month or so; then the temperature at the brine pump began to rise gradually and we could not get it down. We were carrying it at about zero and it began to go up, and stay up. This continued for about a week when it got up to about 16 deg. F. Every morning the chief would ask, "Did you get the temperature down last night?" My answer, of course, was always, "No."

One morning he shook his head and said: "I don't see why you can't get it down." I promptly asked him why he didn't get it down as he knew more about it than I did, but he didn't answer. That day they were going over the system to try to locate the trouble, when somebody put a stick down in the brine tank and discovered that it was partly frozen; then, of course, the trouble was found. The brine was strengthened, and when I came in at night the temperature was down to zero, where it belonged.

Simple, but there may be others who are beginning to operate ice machines.

WILLIAM N. WING.

Brooklyn, N. Y.

Wedge Adjusting Bolt

The illustration shows a wedge bolt removed from the crosshead end of the connecting-rod on a large cross-compound, vertical blowing engine. The bolt broke through at the root of the thread, the thread forming a sort of spring. This thread was strong enough to permit the bolt being backed out of the wedge.

BROKEN WEDGE BOLT

This, as well as other bolts, was made of machine steel. None of them gave any similar trouble on the other engines. An examination showed no shoulder on the strap or brass against which the wedge could have been pulled solid. The bolt was replaced by one of vanadium steel and it is still satisfactory and in daily service.

W. W. PETTIBONE.

Ludlow, Ky.

Frost Covered Generator

F. E. Albrecht's letter and photograph in the issue of Apr. 7 are very interesting. The writer has had turbo-generators in the Southern states where during the day the exhaust end of the turbine was cooler than the generator, but he has never seen such a case of frosting before. I should like to know if this frosting had any effect on the insulation, as one would expect a certain amount

of moisture on the inside of the casing. It would also be interesting to know how the field excitation at the time the photograph was taken compared with that during the summer.

E. R. PEARCE.

Rochdale, England.

Care of Commutators

It is the pride of every man in charge of a generator or motor to keep it clean and free from dirt for it saves him a lot of trouble. It is also his desire to have a good gloss on the commutator and to keep it that way. On some machines the brush-holders are in line with one another, causing the commutator to wear in ridges and finally produce bad commutation. As a result it becomes necessary to turn down or grind the commutator.

After a commutator has been trued up the best thing to do is to stagger the brush-holders. This is done by moving one holder to the outside as far as desired and the next one to the inside, thus every other one is out at the edge of the commutator and every other one is at the inside. Care must be taken to allow for the end play in the machine, so that the brushes do not strike the armature or go out over the end of the commutator bars. Some operators stagger half the holders in line to the outside and the other half to the inside. Thus on a six-pole machine the three top brush-holders would be moved to the outside and the bottom three to the inside or *vice-versa*.

We have tried most every kind of a lubricant for the commutator, and have found a little vaseline on a clean rag to give excellent results. Beeswax and paraffin are liable to make the brushes stick in the holders if too much is used, as it collects on the brushes and cakes in the holders.

In case vaseline is not available a little engine oil on a clean rag gives good results, but care must be taken not to use too much as it will soften the mica.

A. G. CURREN, JR.

Kittanning, Penn.

Filing System

When I first began to keep published articles of particular interest to me, I noted on the cover with blue pencil, "Preserve." But to find an article, it was necessary to look through all the copies, and filing useless matter was also an added objection to this method.

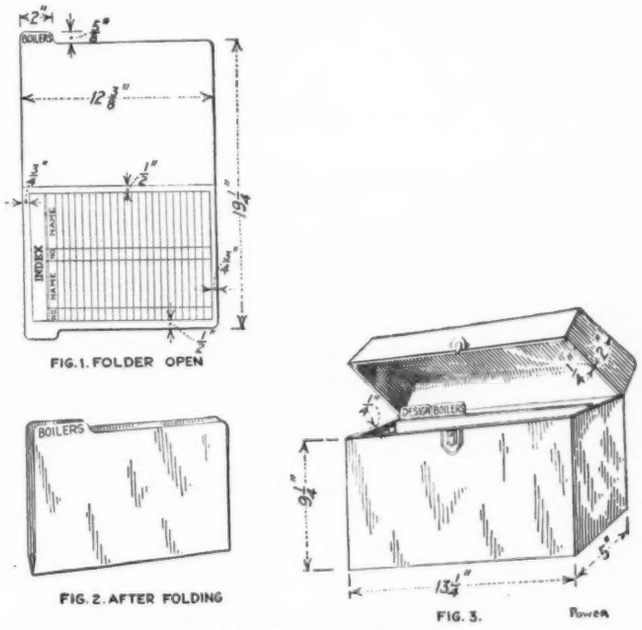
My present method is to take from a journal only such pages as are wanted, and to file each in suitable folders and place in a case. The folders are indexed under the following headings: Steam engines, oil engines, gas engines, steam turbines, boilers and fittings, condensers, superheaters, water heaters, pumps, air compressors, intercoolers, shop methods, foundry methods and appliances, cutting tools, machine tools, small cutting tools, design.

Figs. 1 and 2 show the folder, which was made of heavy drawing paper, folded and shellacked on the outside, this gives it a hard, smooth surface, and prevents soiling. On each folder is printed in black ink the class which it covers. The inside of the cover is ruled with two double columns; the narrow columns for the number of the article, and the wide for the name and description, if any.

The filing case, Fig. 3, is made of seasoned wood, or paper board, painted and varnished, or of metal, and is not much larger than an ordinary letter file. The cover is 2 in. deep, and when thrown back exposes the folders with their classification heads to full view, thus making it easy to pick out the folder desired.

When an article is composed of two or more pages, they are fastened together at the upper left-hand corner with a clip and the number of the article is placed in the upper right-hand corner. This number is also entered in the narrow column of the index. It is not necessary to enter dates, as each page is dated.

To show how simple the system is, suppose you wish to know something about a gas engine, of piston design. You pull out the folder marked "Design," and glance down the index until you find the article. If you were looking for types of gas-engine pistons, instead of something strictly on designs, you would look through the index of the folder marked "Gas Engine." The information, if you have it at all, will surely be found either in the "Gas Engines" or "Design" folder. It is seen that if care has been exercised in classifying, the articles desired can be quickly found.



FOLDERS AND CASE

New folders can be added from time to time. At the end of a year you will have a valuable collection with which you would not care to part.

C. R. COURTENAY.

Watertown, N. Y.

To Make a Tee Square

After making a drawing board and triangles for myself, I bought two 12-in. rulers to make a tee square. I cut one in half and fastened one of the pieces to the full-length ruler with small brass screws. Care was taken to get the head square and true. I now have a neat, graduated tee square which cost only a trifle.

R. G. CURREN.

Kittanning, Penn.

Engineers' Study Course

Elementary Mechanics--XII

Machines

A *machine* is a device by means of which some form of energy is converted into useful mechanical work, or it may be a device whereby a small force may be used to balance a greater force without any work being done by either force. Only machines of the latter type will be discussed at present.

At some point of the machine a force is applied which is utilized in balancing a greater force at some other point in the machine. The force applied is generally spoken of as the *power* or the *effort*, and the force which is balanced is called the *weight* or the *resistance*. The term power, strictly speaking, means the time rate of doing work and as work does not enter into the present discussion the term effort will be used in the consideration of these elementary forms of machines.

Levers

Perhaps the simplest form of a machine is the *lever*, which consists of a bar resting on a fixed point or axis. The fixed axis is called the *fulcrum*, and the distance from the fulcrum to the points of application of the effort and the weight are called the arms of the lever. Thus Fig. 45 represents a lever commonly known as the crowbar or pinch bar. In this case the line DE represents the lever; the point C is the fulcrum; the force P is the effort and W is the weight or the resistance to be balanced. To find the relation between the effort P and the weight W, take moments about the fulcrum C. Thus

$$P \times B = W \times A$$

or

$$P = \frac{W \times A}{B} \qquad (14)$$

The reaction R on the fulcrum of the lever is equal to the sum of the effort and the weight, or expressed as an equation,

$$R = P + W \qquad (15)$$

Example: In Fig. 45, if the distance $A = 4$ in. and

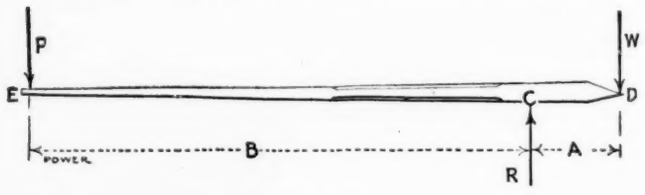


Fig. 45.

the distance $B = 48$ in., what weight W may be balanced by a man exerting an effort of 75 lb. at the point E? This problem is solved by applying equation (14). Thus,

$$P = \frac{W \times A}{B} \text{ or } W = \frac{P \times B}{A} = \frac{75 \times 48}{4} = 900 \text{ lb.}$$

The reaction R on the fulcrum C is the sum of P and W or equals

$$900 + 75 = 975 \text{ lb.}$$

The ratio of the lengths of the arms of the lever is called the *mechanical advantage* of the lever, which, in the above case, is $\frac{48}{4} = 12$. If the length B were smaller than the length A there would be a *mechanical disadvantage*.

Levers are usually divided into three classes, depending upon the location of the effort and the weight relative to the fulcrum. In a lever of the *first class* the *effort* P and the *weight* W are on opposite sides of the fulcrum, as shown in Fig. 45.

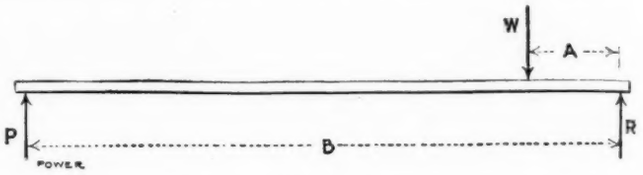


Fig. 46.

In a lever of the *second class* the *effort* P and the *weight* W are on the same side of the fulcrum, the effort being the furthest from the fulcrum, as shown in Fig. 46, where P is the effort, W is the weight and R is the reaction at the fulcrum, which, in this case, is the difference between the weight and the effort, or,

$$R = W - P \qquad (16)$$

In a lever of the *third class* the *effort* and the *weight* are on the same side of the fulcrum, the weight being the furthest from the fulcrum, as shown in Fig. 47, where W is the weight, P is the effort, and the reaction R is the difference between the effort and the weight or,

$$R = P - W \qquad (17)$$

Illustrations of levers of the first class are the crowbar, a pair of shears, the oar of a boat, a claw hammer, etc. A good illustration of a lever of the second class is the wheelbarrow. Here the axle supplies the fulcrum; the effort is supplied by the man at the handles; the weight is the load plus the weight of the wheelbarrow assumed concentrated at the center of gravity of the two. A safety valve of the form shown in Fig. 48 is an example of a lever of the third class, for in this case the effort is the total pressure of the steam on the valve and the weight or resistance is the ball placed at the end of the lever. If the weight of a lever is small compared to the forces acting on the lever, it may be neglected, but in cases such as a safety-valve lever its weight must be taken into account. This may best be illustrated by an example. Thus in Fig. 48 assume the diameter of the valve to be 3 in. and let $L = 30$ in., $C = 3$ in., the weight of the ball $W = 70$ lb., the weight of the lever, $w_1 = 12$ lb. $l = 10$ in. and the weight of the spindle and valve, $w = 6$ lb. What steam pressure will be required to raise the valve from its seat?

Let p be the desired steam pressure in pounds per square inch. The area of the valve equals $0.7854 \times 3^2 = 7.07$ sq.in. and hence the total steam pressure P acting on the valve equals $7.07 \times p$. For equilibrium to exist

the algebraic sum of the moments of all the forces about the point A must equal zero. Thus,

$$w \times C + w_1 \times l + W \times L = P \times C \qquad (18)$$

or

$$6 \times 3 + 12 \times 10 + 70 \times 30 = 7.07 \times p \times 3$$

or

$$21.21\ p = 2238 \text{ and } p = 105.5 \text{ lb. per sq.in.}$$

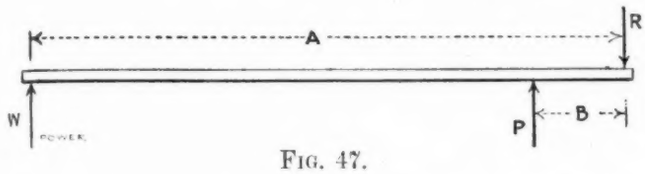


FIG. 47.

Hence a pressure of not less than 105 lb. per sq.in. will be required to raise the valve from its seat. In this problem the pressure or reaction at the pin A equals $P - w - w_1 - W = 746 - 6 - 18 - 70 = 652$ lb. As a general rule the distance l will be about $\frac{1}{3}$ the distance L. However, if desired, the distance l may be determined by taking the lever apart and finding the point D at which the lever will balance.

Still another illustration of a lever of the third class would be the rocker-arm of the Corliss valve-gear of a horizontal type of engine. Here the fulcrum is located at the pin bearing of the lower end of the rocker-arm, the effort is the thrust of the eccentric rod, and the weight is the pull in the reach rod.

The various forms of bell cranks illustrate types of bent levers and the relation between the effort and the weight may be figured as above.

WHEEL AND AXLE

Another common form of machine is the *wheel and axle,* an example of which is the ordinary hoisting drum used in various kinds of construction work. Thus in Fig. 49 let a force P be applied at the handle A of the drum or wheel to overcome the weight W acting at the circumference of the axle whose radius equals R. To

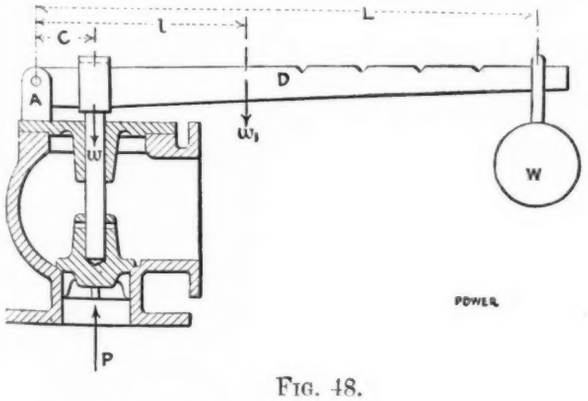


FIG. 48.

find the relation between P and W, take moments about the center O of the axle.

Thus

$$P \times L = W \times R \text{ or } P = \frac{W \times R}{L} \qquad (19)$$

Example: What force P must be applied to overcome a weight W of 500 lb. acting at the circumference of a drum 8 in. in diameter, if the distance from the handle to the center of the axle is 20 in.? In this case $L = 20$, $R = 4$ and $W = 500$; therefore

$$P = \frac{W \times R}{L} = \frac{500 \times 4}{20} = 100$$

STUDY QUESTIONS

51. What weight may be balanced by the use of a crowbar if the fulcrum be located 3 in. from the *c.g.* of the weight, and a man exerts a force of 75 lb. at a distance of 48 in. from the fulcrum?

52. The distance from the axle of a wheelbarrow to the *c.g.* of the total load on the wheelbarrow is 12 in. The distance from the *c.g.* of the load to a point on the handle where a man applies a pull of 60 lb. is 40 in. What load can be balanced by the man?

53. In the above problem, find the pressure of the wheel on the ground when the man supports the handles.

54. In Fig. 48 $C = 4\frac{1}{2}$ in., $l = 15$ in., $w_1 = 25$ lb., $w = 10$ lb. and the diameter of the valve is 4 in. If the steam pressure in the boiler is 80 lb. per sq.in., at what

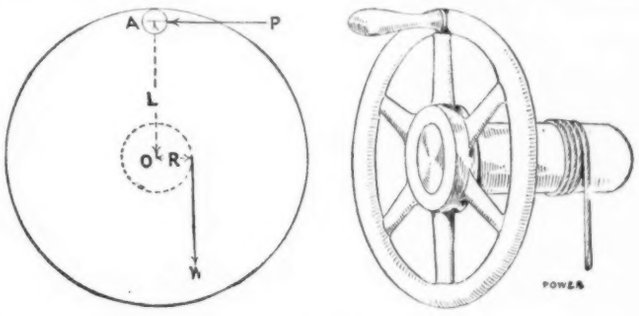


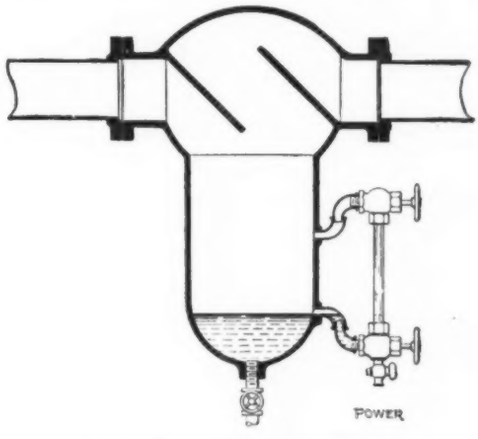
FIG. 49.

point must a ball weighing 100 lb. be placed so as to prevent the valve from lifting?

55. What weight W may be balanced by the application of a force P of 80 lb. when $L = 18$ in. and $R = 3$ in. (see Fig. 49). Neglect all losses.

Separator Gage Glasses

A gage glass on a steam separator connected up as illustrated cannot have a current of steam through it. If the readers of POWER who have separators in which



GAGE-GLASS CONNECTIONS

it is difficult to keep a glass would try this and report results, it would help to decide if it is the current of steam which causes them to break. The lower end of the glass is water-sealed.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The Westinghouse-Cooper Hewitt Co. Ltd., of London, is advertising its silica lamp "as a stimulant to egg-laying." Is this an incentive to Biddy to "see where she's going," or an attempt to break up the door-knob trust?

⁂

Those Why-I-Work-in-a-Power-Plant contest postals are coming in rapidly—and they're great! You fellows who are holding back had better speed 'er up a bit or you'll never get that five-dollar goldpiece to buy one of those two-quart straw kellys to make a hit in your home village. Come, now, climb down off the cracker barrel (or take your foot off the brass rail) long enough to do yourself proud. The contest will close on June 9. The winner's name will appear in the issue of June 23.

⁂

President Wilson is credited with the admission that there's a slump in business. He says there's no good reason for it; the depression is merely psychological. What are those old things we used to hear about innocuous desuetude, meaningless platitudes and glittering generalities?

⁂

This year's report of the National Lighters (meaning electric) committee on progress is a jimdandy—there's no other word for it. It sways with rhythm, bulges with human interest, and just tangoes with fructification. Of course, it must have been the handiwork of our old friend, T. Commerford Martin. May his days be long in the land!

⁂

As a kid, your Uncle Billy was some keen for history; read all the Rollo books, Deadwood Richard, Prescott, Terman's Boilers (Printer: Don't set this "Broilers"), Creasy's Decisive Battles and Lydia Pinkem, but—when was Abraham Lincoln a past president of the New Jersey State Association? Got a photograph here now showing Lincoln, with Marty Hickey of Jersey City, minus his new three-pint kelly; Jack McMorrin, of Newark, Lonely-Road Inspector Calahan, Passaic Krauss and Home-Run Sears artistically grouped about Old Abe. Is this according to the statoots?

⁂

Sir William Willcocks, the Goethals of the Assuan dam, in Egypt, says that in the East graft is respected rather than despised. Too bad the epidemic ever spread to our shores. It's been dammed by many of our engineers, but something's evidently wrong with the structure somewhere.

⁂

Eleven years ago, Samuel Langley witnessed the failure of his flying machine. The ridicule, the sneers and the insults heaped upon this man of splendid courage and faith broke his heart. Today, Glenn Curtiss, at the request of the Smithsonian Institution, has demonstrated that "Langley's Folly" embodied principles of construction that make successful flight possible—it flew! All honor to Curtiss for his vindication of Professor Langley!

⁂

The pumps in the anthracite mines pump more than 3400 tons a minute, or nearly 1,800,000,000 tons of water a year. If this supply were diverted to those promoters who are selling "gold mines" at 59c. on the hoof—good evening, Ignatz!

⁂

"Professor, we'll have to send this coal down to Georgia and have it weighed," said the student at work on a coal-analysis test.

The professor's batting average on humor was about 0.030. "Certainly not!" he declared. "We have the best balances in the country in our laboratory."

"Well, it's written here plainly enough: 'Coal must be weighed in a dry state.'"

⁂

An English correspondent in "Power User" says the following clipping is the last word in steam-plant management:

SAVED BY A ONE-LEGGED MAN—At a meeting of the Dunmow Guardians, the workhouse master reported that owing to the spring season all the able-bodied men had left and a man of 73, who has a wooden leg and is subject to fits, had been called on as the most active male inmate to take charge of the steam boiler and stoke it ten hours a day.

Evidently, the able-bodied men believed in safety first—and skipped!

Installing the First Exhibit at San Francisco

The first exhibit of the Panama-Pacific International Exposition, a 500-hp. Deisel engine manufactured by the Busch-Sulzer Bros. Co., of St. Louis, was installed in the Palace of Machinery on May 27 with impressive ceremonies, in which state and city officials and executives of the exposition participated. Several hundred guests attended.

When Miss Heger, daughter of W. S. Heger, Pacific Coast manager of the Busch-Sulzer Bros. Co., pulled the lever which set in motion the machinery of the giant pile-driver, cheer after cheer rent the air and united with the reverberations from the impact of the steam hammer upon the top of the first pile to be driven in the Palace of Machinery.

Mr. Heger opened the ceremonies by a short address of welcome, and was followed by Capt. Asher Carter Baker, U. S. N. (retired), director of the division of exhibits, who formally accepted the exhibit and presented a deed to Mr. Heger granting the company the right to the central space in the palace.

"We have had many ceremonies here on many various occasions since the day President Taft broke ground for the exposition, but none that was more important than this," said Captain Baker. "There are three phases in the life of an exposition: the construction work, the installation of exhibits and the period during which both the buildings and the exhibits are displayed to the world.

"Today, nine of the principal exhibit palaces are completed and are accepted by the division of works. This marks the near close of the construction period, and the installation of this exhibit at this time, nine months before the opening day, demonstrates the unparalleled progress of the exposition. It is eminently fitting and decidedly appropriate that the first exhibit to be installed should be a Diesel engine, the product of an American manufacturer, and a marvel of mechanical science, which has opened up a new field for the marketing of an important California product, crude oil. It was only recently that the first transoceanic ship equipped with a Diesel engine was launched and on her initial voyage made San Francisco a port of call, loading with California oil."

Lieutenant-Commander Clark Howell Woodward, U. S. N., delivered an interesting talk on the "Use of the Diesel Engine in the Navy." He called attention to the fact that two sister ships are now being built at the Mare Island Navy Yard, the "Maumee," to be equipped with a Diesel engine, and the "Kanawha," with a steam engine, and that this would be an excellent test of the comparative advantages of the two types of engine.

⁂

Annual Convention of National District Heating Association

The sixth annual convention of the National District Heating Association was held at the Hotel Seneca, Rochester, N. Y., on May 26, 27 and 28. It was attended by about 150 members, representing district heating plants of many localities. A notable feature of the convention was the large number of papers presented by men who are actively engaged in district heating engineering, the character of the addresses, papers and discussions signifying that the problems of district installations and operation are being met with a high order of engineering intelligence, skill and perseverance.

The first session was called to order by President S. Morgan Bushnell, Chicago, Ill. In the absence of the mayor the members were welcomed to Rochester by Commissioner of Public Safety Charles E. Owens. A report presented by Secretary-treasurer D. S. Gaskill showed the organization to be in good financial condition. The applications which were favorably acted upon increased the membership to 300.

In his address to the association, President Bushnell commented on the fact that central-station heating was at first regarded as an unwelcome consideration by managers of central light and power stations, who were inclined to avoid the heating problem. It is only within a comparatively few years that there has been an organized effort to collect and systematize information on central steam and hot-water heating projects, to place them on a scientific basis compatible with their economic importance. Figures were quoted showing that it is highly improbable that central steam and hot water systems would be outrivaled by other methods of heat distribution, and especially by electricity, as the cost was about eleven times the cost which has been established

for distribution by steam and hot water. Referring to gas as a competitor, the president thought this was a negligible consideration excepting in those districts which are favored by a supply of natural gas. The president also stated that the comfort, convenience, cleanliness and actual economy of central heating are already appreciated by thousands of satisfied customers, and benefiting by the experience of the plants already in existance, it is safe to predict a rapid increase in the number of installations. The statement was made that the capital invested in central station heating now runs into the millions and the number of companies engaged has been estimated at from 300 to 400.

The leading papers and discussions were: Report of Meter Committee; Hot Water Heating Under Forced Circulation; Expense of Operating Centrifugal Pumps, vs. Double Acting Pumps; Some Effects of Utility Regulations as Affecting District Heating; Effect of Superheated Steam on Heating Systems; District Heating for Small Towns and Cities; Heat Losses from Buildings of Latest Construction; Which is More Profitable, to Shut Off Steam at Night or Keep It on Continuously?; Economic Advantages to Consumers of Central Station Heating Service over Individual Heating Plants; Report of Rate Committee; Customers' Steam Heating Systems; Commercial Steam Heating in New York City; Report of Educational Committee; Report of Station Operating Committee.

The officers elected for the coming year follow: President, H. R. Wetherell, of Peoria, Ill., first vice-president, D. S. Boyden, of Boston; second vice-president, B. T. Gifford, of Grand Rapids; third vice-president, G. W. Martin, of New York city; secretary and treasurer, D. L. Gaskill, of Greeneville, Ohio; excutive committee, S. Morgan Bushnell, of Chicago; H. Almert, of Chicago, and C. F. Oehlmann, of Denver

Professor James D. Hoffman, M. E., past president of A. S. H. and V. E., Mem. A. S. M. E., formerly of Purdue University and now professor of mechanical engineering, University of Nebraska, was elected an honorary member of the association, in recognition of his contributions to the science of district heating

Special entertainment for ladies was provided in auto tours, a trip on Lake Ontario and card parties. A theater party on Wednesday evening and an informal reception on Thursday evening were largely attended by members and guests. On Thursday afternoon a visit of inspection was made to the factory of the Taylor Instrument Co. and on Friday the entire convention, as a guest of the American District Steam Co., went by special Pullman train to Niagara Falls, stopping en route at Lockport, where the first district heating plant was installed. After spending Friday afternoon in sightseeing at Niagara Falls, the members and guests returned to Rochester and the convention was brought to a close.

Power for Steel Mills

SYNOPSIS—There appears to be a wide discrepancy between actual performances and the alleged possibilities of the blast-furnace gas-engine driving alternating-current generators. Some of the deficiencies are pointed out and comparisons are made with a steam-turbine plant.

Before a joint meeting of the Chicago section of the American Institute of Electrical Engineers and the electrical section of the Western Society of Engineers on April 27, F. G. Gasche, mechanical engineer of the Illinois Steel Co., delivered an interesting lecture on the blast-furnace gas engine as a prime mover for driving alternating-current generators. Due to the discrepancy between actual performances and the alleged possibilities which is now agitating steel mill engineers the subject is timely. It was discussed by Mr. Gasche under the following subdivisions; The laws of thermodynamics, the direct commercial problem and the serviceability of the equipment.

THEORETICAL EFFICIENCIES

Among other things it is known that the limit of thermodynamic efficiency is expressed by the difference of the initial and final temperatures of the working fluid divided by its initial absolute temperature. In the entire domain of prime movers there is available a temperature range of 3000 deg. F., approximately. The conversion of heat into work throughout this range in any one prime mover is physically impossible.

The lower limit of temperature, for average steam-turbine practice, is approximately 80 deg. F. The exhaust from gas engines is rarely under 1000 deg., notwithstanding the enormous water-cooling effect applied to cylinders, ports and valves, but the final temperature of expansion, as the incident of conversion of heat into work by expansive use of the gas, can seldom be less than 1200 deg. F. The limit of thermodynamic efficiency of this type of prime mover, which cannot be approached by a wide margin, is

$$100 \times \frac{3000 - 1200}{3460} = 52 \text{ per cent.}$$

Modern steam turbines of suitable design and capacity may be successfully operated with initial steam temperatures of 700 deg., which with a condenser temperature of 80 deg., gives a maximum thermodynamic efficiency of

$$100 \times \frac{700 - 80}{1160} = 53.5 \text{ per cent.}$$

This cannot be approached on account of practical limitations.

It will be noticed that the temperature range for the gas engine is incapable of material extension without the indulgence of expansions and cylinder dimensions already prohibitive because of mechanical and commercial limitations. Consequently, no material improvement of inherent thermodynamic efficiency is a possibility for the gas engine. On the other hand, there is a wide gap in the temperature range (700 to 1200 deg.) not at present utilizable by any type of prime mover, and which is the exclusive prerogative of the turbine if speculation is made on the tendencies of design.

During the early days of the gas-engine much emphasis was placed on the assertion that with the new type of prime mover no steam boilers would be required. But the enormous jacket-water heat losses were unpopular as a subject of comment. Much stress was laid on the high initial temperatures of working fluid to which the gas engine would be devoted, but no comment on probable high temperatures of exhaust could be indulged. Many dissertations appeared concerning use factor, load factor and efficiency without a suggestion of the hospital records of sick gas engines, and the long periods of convalescence after an exhibition run. Nor was there a suspicion of the disastrous effects on every other prime mover by the injection of the hit-or-miss, impactive, threshing influence on a whole power circuit in the name of an exponent of high thermal efficiency.

ACTUAL PERFORMANCE

In comparing the actual performance of blast-furnace gas engines driving alternating-current generators with the actual performance of turbine-driven units, Mr. Gasche had personal knowledge of the performance of four 2000-kw. gas engines operating for a period of three months with the most favorable conditions for a constant and rated load. Meanwhile, all of the peak loads and variations were assumed by a large turbine in the vicinity. All the fuel gas was measused by a large venturi meter. Statements of the thermodynamic efficiency of larger installations have been uniformly pure fancies of interpretation in the absence of any means for measuring the aggregate gas supply. The coefficient of flow of this venturi meter is known within one per cent. error. Under such circumstances the energy at the switchboard was 19.2 per cent. of the energy supply of the gas.

A recent publication ("Stahl und Eisen," No. 51, 1913) shows an over-all thermal efficiency of boilers, turbine and generators of 13.63 per cent. with long continued service and extremely variable loads. With conditions of load as favorable as that recited for the gas engine plant, the over-all thermal efficiency would be at least 14.5 per cent. On the basis of 19.2 per cent. and 14 per cent. the relative fuel demands of gas engines and turbines for steel mill loads would stand approximately in the ratio of

$$\frac{14}{19.2} = \frac{1}{1.371}$$

that is, the steam turbine would require 37 per cent. more fuel for the same output. Whether this quantity is more or less, a deliberate examination of the contemporaneous performances of different types of plant, or of their relation even ten years ago, will show that the extravagant claims concerning the fuel savings by gas engines were never justified.

The statement was made about the time of the installation of the larger gas-engine plants that the turbine would use at least 2½ times the fuel required by the former, and today exponents of gas engines assert that the ratio is at least 2 to 1.

INVESTMENT

The direct commercial problem of investment is contemporaneous, since some improvement in both gas engines and steam turbines is to be expected. A promising development of the former consists in the so called scavenging process, being essentially the more complete removal of burnt gases by an injection of air into the gas cylinders previous to the entry of the explosive charge. The rapid advances in the use of high pressures and high superheating of steam is responsible for turbine performances which promise thermal efficiencies fully as high as the best performance of gas engines. Steam boilers and their equipment are receiving a concentration of attention, such that the attainable performances of gas producers will be permanently surpassed.

Attempts have been made to increase the capacity of gas engines by the indulgence of high piston speeds, and thereby decrease the unit cost. The inertia stresses on large gas engines are already high and any movement for their increase in this manner will meet with opposition. Taking the records of the past as some indication of the prices that may be demanded in the future, and with the additional consideration that the overload capacity of the gas engine is limited to about 25 per cent., the investment situation may be summarized as follows:

A steel mill power plant of gas engines will require such an installation adequate for all peak loads that the cost per kilowatt based on average mill load will be at least $100. Turbine installations for the same character of mill load, and adequate for all peak loads, will cost not more than $55. The relative fixed charges will, therefore, be in the ratio of 55 to 100, or 1 to 1.82. Taking the cost of fuel for the steam turbine plant at $0.003 per kw.-hr., and a 6000-hr. service per year, the fuel cost would be as follows:

Steam turbines	$18.00
Gas engines	15.00

The difference in favor of gas engines is $4.90 per kilowatt per year. Taking the fixed charges of both plants at 15 per cent., the annual charge per kilowatt would be

Steam turbines	$8.25
Gas engines	15.00

The difference in favor of the turbine is $6.75. The advantage of the turbine plant over the gas-engine plant, considering simply fuel demands and fixed charges, amounts to $1.85 per kw. per year. A consideration of operative expense, supplies, etc., will further widen the gap between turbines and blast-furnace gas engines to the advantage of the former.

The iron and steel business has been called the "barometer of trade," with the implication that periods of depression and good times alternate. A power-plant equipment sufficient for the maximum demands of business must of necessity exhibit a number of idle prime movers in periods of depression. Leaving aside the reasonable provision of spare units for repairs and maintenance conditions, it is manifest that a type of prime mover requiring a heavy investment constitutes a serious encumbrance to the business during times of depression, because of the heavy fixed charges. A power plant having an additional investment of one million dollars over the requirements of another type of equipment will cause a loss at the rate of $150,000 per year, approximately. Periods of business depression can easily be encumbered with interest losses which, in the aggregate, would buy much of the fuel required by steam equipment during prosperous times.

SERVICE

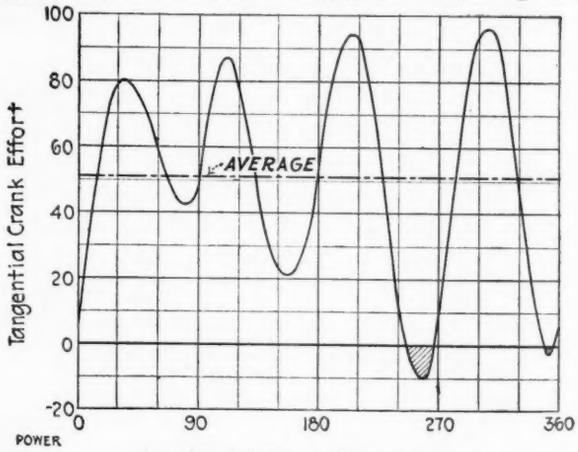
If infatuation for the supposed thermal advantages of the gas engine had not disarmed all discretion, there would not be the array of incongruities now displayed in the attachment of a four-stroke-cycle gas engine, even of the four-cylinder, double-acting type, to an alternating-current generator. This service by all industrial and commercial considerations should give emphasis to uniformity of speed, momentary as well as for average conditions. Take an engine operating at 83 r.p.m., with the four-stroke-cycle action. One stroke in four is effective, and the three preceding, representing a time lag of 2.7 seconds, must attend any attempted readjustment of valve gear to suit a change of load, assuming an instantaneous movement of a governor. The movement of a governor throughout its range can scarcely occur in less than half a second, such that with perfect adjustment and design of the gas engine as a whole it cannot respond to a change of load beyond the small capacity of a flywheel in less than 3 seconds.

It may be considered that the multiplicity of cylinders and cranks giving an impulse twice for each revolution would alleviate this trouble, but reference is made to changes of load, at which time all cylinders are subject to the same time lag due to the four-cycle action. The significance of this time lag will be apparent to the electrical engineer when the character of load imposed on a steel-mill power plant is realized. An installation of any magnitude would ostensibly contemplate service to motor-driven rolling mills possessing peak load characteristics the severity of which is without precedent or duplication in any other industrial application of electric power. Single operations on a roll train may require energy delivered at a rate of 8000 hp. for three seconds or less. A multiplicity of motor-driven mills may, by nonsynchronous operations, minimize the time and magnitude of peak load requirements on the power plant, but, unfortunately, there is nothing to prevent the superposing of peak loads on the power plant and in very short intervals of time. Under such circumstances, the time lag characteristic of the four-stroke-cycle gas engine renders it incapable of maintenance of reasonable uniformity of speed, and there results disastrous effects on the whole electrical power system. As to providing sufficient flywheel effect on the gas engines, it may be stated that the peak loads in such a plant could be sustained by energy from flywheels for about one second after which additional effort is required of the gas engine and probably beyond the capacity of any practicable number of power units.

CRANK EFFORT DIAGRAM

In crank effort diagrams of steam engines there is more or less deviation from an average value, which is properly provided for in a suitably large flywheel. In the four-stroke-cycle, double-tandem and quarter-crank blast furnace gas engine, operating with a constant load on the generator and with equal and practically perfect gas distribution on both sides of each piston, the crank effort diagram is of the remarkable form here shown.

The ideal crank effort diagram as thus developed is seriously distorted in any actual gas engine of this type because of the inability of the engine to produce such indicator diagrams under "man power" regulation is startling in the absence of any possibility of automatic regulation with change of load. There are four large torque values and two minimum values which are less than zero. In other words, the ideal adjustment of the ideally perfect construction still imposes that twice in each revolution the flywheel must drag the crank and reciprocating parts, and at the same time carry the load on the engine.



CRANK EFFORT DIAGRAM

Flywheels of suitable capacity to accomplish these extraordinary results must be so large that the structures are physically and commercially preposterous, since they cannot be selected alone from consideration of inertia effects. In all cases, prior consideration must be given to the natural and forced frequencies of the gas engine and generator combined, such that the natural periods of oscillation of the wheels do no lead to resonance effects.

The mechanical efficiency of the double tandem gas engine at fractional loads has proved a disappointment, while even for full load it is seldom as high as 85%. The enormous friction loss has a serious effect at fractional loads such that a load factor of 70 per cent. will, in all probability, be attended by an over-all thermal efficiency not exceeding 15 per cent. for the plant.

There is now an opportunity for the optimism with which the engineer should approach such a discouraging outlook. The "legacy" of the gas engine installations is on hand with the one fortunate circumstance that they are not of sufficient capacity for the plants which they serve. Additional equipment of gas engines will not correct inherent defects of the type of prime mover, but a suitable addition of steam turbine equipment will minimize their influence.

In practically every steel plant of the magnitude where gas engines became a habit, there are immense quantities of heat from open hearth furnaces, heating furnaces, etc., which can be effectively applied to steam generation. Delivery of this to steam turbines of a suitable type will favor the production of enough electrical energy to rehabilitate the power-plant service.

DISCUSSION

In the discussion following, all, with two exceptions, were in accord with the author of the paper.

W. B. JACKSON had not had occasion to figure on gas engines of such large capacity, but on units rated at several thousand kilowatts he would recommend a steam plant. In his opinion, the development of the gas engine had been worth while, because it is a deviation from the steam cycle and one step toward the great improvement that must be made in the conversion of heat into electrical energy. The day must come when instead of getting from 3 to 22 per cent. of the energy in the coal, the electrical output will closely approximate the initial energy.

E. W. ALLEN stated that the product of the gas engine did not compare favorably with that of the steam turbine plant. He had looked into the records of a large gas-engine plant and found that the fluctuations from a normal load of 45,000 kilowatts were as high as 15,000 kilowatts. These deviations in load resulted in a change of speed which effected the frequency. Such service might perhaps do for steel mills but not for other plants. Better results would be obtained with the more uniform frequency attained in steam plants. A storage battery would tend to relieve the situation, but the cost of a battery to handle more than 30 per cent. of the load would be excessive.

T. MILTON, a representative of a storage battery company, had observed the operating conditions of a plant having ¼ mile of gas engines and in his opinion the solution of the problem was to put in enough storage batteries to give the gas engine a steady load. Within 3 seconds he had seen a battery swing from 30,000 amperes discharge to 13,000 amperes charge. A battery will care for sudden and heavy changes of load, and if there were enough battery capacity in the plant the change in load could be handled in 1/10 seconds.

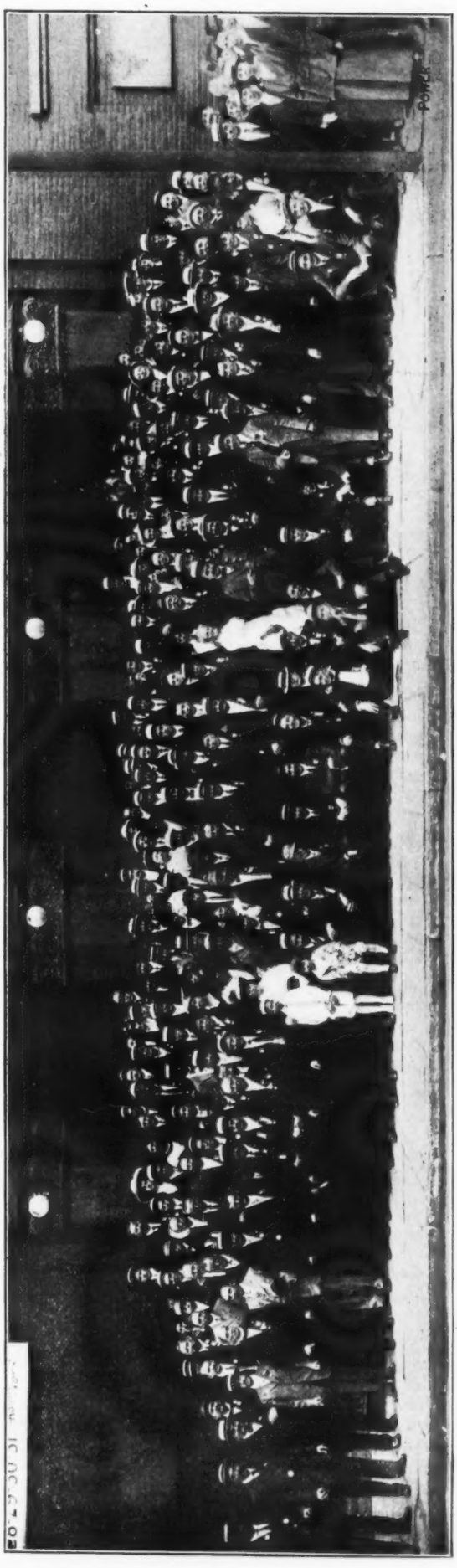
O. H. WEST referred to the Gary plant, in which there are 43 gas engines ranging in capacity from 3500 to 4500 kilowatts. The power cost in this station is less than any other plant of the United States Steel Corporation. One of the advantages of the gas engine unit is the rapidity with which it may be started. He had seen them brought up to speed and synchronized on the bus bars in 30 seconds. In operation the regulation has been greatly improved. With the improved governor the speed can be maintained closer than 8 per cent. When a gas engine is thrown from no load to full load and vice-versa.

MR. GASCHE, in reply, admitted that a steady load applied to a gas engine by an alternating-current generator with storage-battery service would be ideal, but no steel plant has a steady load nor can it be prescribed when the peak loads will come. If this were possible, more units could be put on to handle it. With such variable loads from the mill trains on and off so quickly a storage battery would be seriously embarrassed, and unless it had a capacity beyond all reasonable proportions to the load, it would be of little use. As to the time of putting these large gas engines into service, he had seen it done in 1½ min., but the usual time was 2½ min. In reply to a question as to the proper capacity of steam-turbine plant to handle the peak loads of a gas-engine plant, the proportions of 30 and 76 per cent., respectively, were given.

New Jersey N. A. S. E. Convention

From Thursday, May 28, to Sunday, the 30, N. A. S. E. men of New Jersey and the vicinity enjoyed the twenty-third annual convention and exhibit in Elks Hall, Jersey City.

State President Jenkinson called the eleven associations in the state to order for the opening business session at 3:00 p.m. Saturday. At this time the various committees presented



SOME OF THOSE IN ATTENDANCE AT THE NEW JERSEY N. A. S. E. CONVENTION IN JERSEY CITY

their reports, most important of which were the reports of the educational and legislative committees. The former committee's report showed most commendable results for the year, although only three-fourths of the money appropriation was used. The legislative committee reported that the bureau which will examine candidates and issue licenses under the new state engineers' license law was being prepared for organization by the Commission of Labor.

The beefsteak supper Saturday evening was thoroughly enjoyed by everyone. It is not often that ladies participate in a beefsteak supper, where "fingers before forks" is the rule, but here the fair ones in large white aprons and comic headgear found pleasure.

On Friday evening a smoker, including cabaret talent and refreshments, was given by the exhibitors, who also furnished the refreshments after Saturday's session.

The speakers of the evening were: National President James R. Coe; Assemblyman Griffin; Charles H. Bromley, chairman of the educational committee; Henry D. Cozens. First National President and National Trustees Joseph Carney and William Reynolds. Entertainment was furnished by Jenkins Bros. and Jack Armour of "Power," under the direction of Frank Martin.

On Sunday morning the business was resumed, the following officers being elected: President, Charles Summer, Hoboken; vice-president, Dennis F. Bartley Jersey City; secretary, James S. Heath, Elizabeth; treasurer, Thomas Brown, Newark; conductor, Arthur Truman, Atlantic City; doorkeeper, William T. Brown, Jersey City.

Master Boiler Makers' Eighth Annual Convention

The eighth annual convention of the Master Boiler Makers' Association and the Boiler Makers' Supply Men's Association was held in Philadelphia, Penn., May 25 to 28, inclusive, with headquarters at the Hotel Walton; the convention hall was on the tenth floor.

The convention was called to order at 2:30 p.m., on Monday, the first day, and after the invocation by Bishop Joseph F. Berry, addresses were made by Mayor Blankenburg, S. M. Vauclain, vice-president and general manager of the Baldwin Locomotive Works, and Ivy D. Lee, chief executive assistant to the president of the Pennsylvania R.R. Responses were made by M. O'Connor, past president, C. P. Patrick, fifth vice-president, and G. W. Bennett, past president. These were followed by the president of the association, T. W. Lowe, with his annual address. The rest of the session was given up to reports and miscellaneous business. During the afternoon a joint meeting of the Supplymen's Association and the Philadelphia committee of arrangements was held. In the evening the eighth annual reunion, reception and dance was held in the ballroom of the hotel.

The second day's session was devoted to addresses by S. G. Thompson, superintendent of motive power and railway equipment of the Philadelphia & Reading R.R., and Frank McManamy, chief boiler inspector, Interstate Commerce Commission. Mr. McManamy urged that a closer coöperation and more amiable relations between the officials and inspectors of the Interstate Commerce Commission and the manufacturers of steam boilers be brought about, so that a more intelligent understanding of the requirements of the Federal law might obtain, which would reduce the fatalities and casualties due to faulty boiler construction

GROUP OF MASTER BOILER MAKERS, SUPPLY MEN AND GUESTS ON THE LAWN OF THE RESIDENCE

The next convention of the State Association will be held in Trenton in May, 1915.

The exhibits were most commendable, all the booths being well arranged. The exhibitors were:

Republic Flow Meters Co.	W. B. McVicker Co.
Dearborn Chemical Co.	R. & J. Dick, Ltd.
John A. Roeblings Sons Co.	Jenkins Bros.,
Quaker City Rubber Co.	"POWER"
Charles V. Hoffman	Griscom-Russell Co.
The Philadelphia Grease Mfg. Co.	Theodore Smith & Sons Co.
Standard Regulator Co.	Buhne Metal Packing Co.
Donegan & Swift	The Lunkenheimer Co.
The Fairbanks Co.	Greenpoint Fire Brick Co.
Voorhees Rubber Mfg. Co.	F. W. Webb Mfg. Co.
A. & F. Brown Co.	H. W. Johns-Manville Co.
Ross & Taggart	Cherry Chemical Co.
Strong, Carlisle & Hammond Co.	Smooth-On Mfg. Co.
The Texas Co.	C. I. Coe Co.
Garlock Packing Co.	John Simmons Co.
Armstrong Cork & Insulation Co.	O'Rourke Sheet Metal Co.
Greene, Tweed & Co.	Mueller Mfg. Co.
Pitts & Kitts Mfg. & Supply Co.	Keystone Lubricating Co.
William Van Keuren	Albany Lubricating Co.
Consolidated Safety Valve Co.	De La Vergne Machine Co.
McLeod & Henry Co.	Otis Elevator Co.
Ladies' Auxiliary of N. J.	Homestead Valve Mfg. Co.
Goldschmidt Thermit Co.	Belmont Packing Co.
Hazard Mfg. Co.	LeBaron B. Johnson
Clipper Belt & Lacer Co.	Peerless Rubber Mfg. Co.
Gibson Iron Works	The Richardson-Phenix Co.
A. B. See Electric Elevator Co.	

Where Dirt Has Its Use—Don't try to keep the melted babbitt clean, no matter if there is dirt, coal and other refuse on the surface. Let such dirt stay there. Ofttimes it is well to throw in a little dirt of this sort if the metal is clean. This is for the purpose of preventing oxidation of the babbitt. Oxidation causes a lot of dross to form and uses up a corresponding weight of babbitt. Covering the top of the babbitt pot to keep the air from the hot metal will prevent considerable of the dross forming.—"Gas Review."

The trend of the speakers in discussing the question was to the effect that boiler makers should change their attitude toward the Federal inspectors and to either obey the Government inspection law and the orders of the commission, or present to the Government good reasons for not doing so

Mr. McManamy emphasized the fact that the interests of the railroads, the manufacturer and the Government officials are common, and that they are all working for increased efficiency in serving the public. No law for safeguarding life, said the speaker, had been so successful as the present inspection law, which during the first year of its enforcement decreased the loss of life 60 per cent. on railroads, and in the last nine months compared with the nine months of last year the reduction has been 48 per cent.

Then followed the committee's reports on the following subjects:

"What Are the Advantages or Disadvantages of Using Oxyacetylene and Electric Processes for Boiler Maintenance and Repairs?"

"What Benefit Has Been Derived from Treating Feed Water for Locomotive Boilers Chemically, etc.?"

"What Can the Association Do to Get a Uniform Rule Regarding the Load Allowed on Staybolts and Boiler Braces?"

"The Advantage or Disadvantage of Combustion Chambers in Large Mallet or Pacific Type Engines Other than a Shorter Flue."

In the afternoon the committee reported on the following:

"What Shape and Size Head of a Radial Staybolt in the

Crown Sheet of Oil Burning Engines Gives the Most Efficient Service?"

"Does the Method of Flue Cleansing or Rattling Have Any Effect on the Further Scaling up of Flues?"

"Combustion and Fuel Economy."

"The Proper Inspection of a Boiler while in Service."

While the convention was in session, an automobile trip and luncheon were given to the ladies. In the evening a theater party was held at Keith's Theater.

All business was suspended on Wednesday, the third day of the convention, to accept the invitation extended to the members of the convention and Supplymen's Association, and to their ladies and guests to visit the plants of the Parkesburg Iron Co., Parkesburg, Penn., and the Lukens Iron & Steel Co., Coatesville, Penn. About 500 persons made the trip in a special train. Lunch was served in a large tent on the lawn at the residence of A. F. Huston, president of the Lukens Co. An address of welcome was delivered by Mr. Huston, to which T. W. Lowe, president of the Master Boilermakers' Association, responded. After inspecting the plant the party left on the return trip at 5:30 p.m.

In the evening there was an entertainment consisting of vaudeville and a lecture, illustrated by motion pictures, on Panama, by Frederick Poole.

The session of the fourth and last day was opened by an address by Henry T. Hartley, past president of the American Boiler Manufacturers' Association and superintendent of the boiler department of the William Cramp & Sons Ship & Engine Building Co. He contrasted modern boiler construction with that of several decades ago and pointed out the improvement and advancement in the construction of steam boilers.

The election of officers for the ensuing year concluded the convention, at about one o'clock. They are as follows: James T. Johnston, Los Angeles, Calif., president; Andrew Greene, Indianapolis, Ind., first vice-president; D. A. Lucas, Havelock, Neb., second vice-president; John B. Tate, Altoona, Penn., third vice-president; Charles T. Patrick, Cleveland, Ohio, fourth vice-president, and Thomas Lewis, Sayre, Penn., fifth vice-president. Harry D. Vought, of New York, was reëlected secretary, and Frank Gray, of Bloomington, Ill., reëlected treasurer. The members elected to the executive board were Harry Winterstein, Harry Weldin and Thomas T. Powers.

Secretary Vought reported that 48 new applications had been made for membership during the convention, and that 23 members had been received into the association since the last annual convention, a gain for the year of 71 in new members.

Thursday afternoon was given over to an automobile trip for the ladies to points of interest, and to a visit to the Baldwin locomotive works by the members and guests of both associations. The trip was made in automobiles to the works, where an interesting afternoon was spent. A banquet was tendered to the Master Boiler Makers' Association by the Supply Men in the banquet hall of the hotel as a fitting closing of a successful gathering in convention of boiler makers from various parts of the United States and Canada.

The Largest Pumping Station—It is stated that the pumping station for the Jefferson and Plaquemines Drainage District in Louisiana will be the largest in the world, having an ultimate capacity of 900,000,000 gal. in 24 hours. There will be installed four 76-in. pumps of 192,000,000 gal. capacity each and two 48-in. pumps of 64,000,000 gal. each per day.

Recent Court Decisions

Digested by A. L. H. STREET

Service Rates in Arizona—The law enacted at the 1912 special session of the Arizona Legislature requiring electric companies to afford service on the meter basis, was lately held by the state supreme court to be invalid, as violating the provision of the Arizona constitution which vests power in the Public Service Commission to fix rates for such service. (State vs. Tucson Gas, Electric Light & Power Co., 138 "Pacific Reporter," 781.)

Cancellation of Patents to Public Lands—Patents granted by the United States covering public lands entered as mining claims are subject to cancellation on proof that the lands were actually entered on account of water power thereon, and not for mining purposes, according to the decision of the United States Circuit Court of Appeals, Ninth Circuit, in the recent case of Multnomah Mining, Milling & Development Co. vs. United States, 211 "Federal Reporter."

West Virginia Public Service Commission—The scope of the powers of the West Virginia Public Service Commission was lately the subject of consideration before the supreme court of the state, in the case of United Fuel Gas Co. vs. Public Service Commission, 80 "Southeastern Reporter," 931. It was decided that, although the supreme court of appeals has jurisdiction to review an order adopted by the commission, in an original proceeding brought for that purpose, no order may be disturbed unless it appears to be beyond the statutory or constitutional powers of the commission, or that it was based upon a mistake of law made by that body. An order based upon what the commission deems to be best for the public interests is final and not reviewable by the courts. The supreme court of appeals will not disturb an order prohibiting discrimination in fuel gas rates based solely upon the question of whether the consumer has contracted to take service for a period of five years or is not committed to take it for any definite time.

Warranty of Power Plants—Two important legal principles applicable to sales of power machinery were involved in the case of the General Electric Co. vs. Alderson, 210 "Federal Reporter," 775, recently passed upon by the United States Circuit Court of Appeals for the Fourth Circuit. One point is that the plaintiff, in contracting to manufacture and install in a building at Charleston, W. Va., a power and lighting plant, in accordance with definite specifications, did not impliedly warrant that the plant was adapted to the particular building. The other point is that, where a contract to sell machinery contains express warranties concerning it, the parties will be presumed to have expressly stipulated all the warranties that were intended to be made and none will exist by implication. Incidentally, the court concludes in the same case that a warranty "that the turbine and generator connected therewith will run continuously at its normal rated capacity without undue heating, undue noise or vibration," relates only to the performance or behavior of the particular machinery as such, and not to the effect of its operation upon the building in which it was placed.

OF A. F. HUSTON, PRESIDENT OF THE LUKENS IRON & STEEL CO., COATESVILLE, PENN.

Two Serious Explosions at Detroit

On May 9, two men were fatally injured by the explosion of a boiler at New Baltimore, Mich., at the Detroit United Ry. (Shore Line) power house.

The boiler in question is a Babcock & Wilcox horizontal water tube, and is rated at 300 hp., having nine horizontal rows of 16 tubes, each 4 in. in diameter.

A new steel mud drum $\frac{5}{8}$ in. thick, having an internal cross-section of 6x6 in., was recently installed, taking the place of a cast-iron mud drum. This was attached to the serpentine headers at the rear by sixteen 4-in., extra-heavy nipples, 4¼ in. long. Fifteen of these nipples were firmly retained in the headers of the boiler and one in the new mud drum. The tube holes in the new header were fairly uniform in size, but tapered, being $\frac{1}{32}$ in. larger at the outside of the hole. This was probably the prime factor in causing the failure.

It is evident that, in machining the tube holes, a cutter was used that had worn somewhat tapered. This condition would make it difficult to expand the tubes so as to make the job safe and secure. The boiler otherwise was in first-class condition, and the gereral maintenance of the plant was excellent.

On May 13, one life was lost in the plant of the Detroit Copper & Brass Co. One of the front tubes of a Wickes boiler became obstructed by pieces of scale, which blocked the tube about 1½ ft. above the lower drum, and when the water evaporated, the tube fused and the contents of the boiler were discharged into the dutch oven furnace, having a Murphy stoker. The front tubes were overheated and their elongation put a severe stress on the tube sheet, the stay-rod construction being rigid the stress caused the failure of more than half of the crow feet in both drums, breaking them at the bends and dishing the tube sheet top and bottom about ¼ in. The row of tubes in front of the furnace was pushed through the tube sheet about ¼ in., and one tube was found to be entirely pulled out of the lower tube sheet upon cooling the boiler.

It will thus be seen what heavy stresses can be caused by long tubes and rigid construction. A similar accident would not have occurred under the same circumstances had the present construction of the Wickes company been used, which provides for a minimum section of stays throughout the major part.

ENGINEERING AFFAIRS

The National Association of Corporation Schools will hold its second convention in Philadelphia, June 9, 10, 11 and 12. The association was organized in New York, Jan. 24, 1913, "to aid corporations in the education of their employees, (1) by providing a forum for the interchange of ideas and (2) by collecting, and making available, data as to successful and unsuccessful plans in educating employees." Arthur Williams, New York Edison Co., is president. The membership approaches 150 in all classes, covering 32 different industries.

Preparing for the Boiler Manufacturers' Convention—The Supply Men's Association of the American Boiler Manufacturers' Association, which has in charge the social features of the program for the convention to be held in New York City, Sept. 1 to 4, has the plans for it pretty well worked out. Two meetings have been held in New York and an executive session in Philadelphia to arrange for the program and the financing of the entertainment. At a meeting June 2 in the Waldorf-Astoria, Chairman Thomas Aldcorn, Secretary T. B. Slocum and Treasurer D. J. Champion reported on the work already done and a tentative program was adopted.

The Seventh Annual Picnic and Field Day of the combined associations of the N. A. S. E., of Brooklyn, N. Y., took place at Juniper Park, Maspeth, L. I., on Sunday, May 31. The associations comprising the combination are the Modern Science Club, Brooklyn Council No. 8, U. C. C. of E., Melville Council No. 9, U. C. C. of E., Brooklyn Association No. 8, N. A. S. E., Brooklyn Association No. 27, N. A. S. E., Brooklyn Association No. 41, N. A. S. E., Brooklyn Association No. 57, N. A. S. E. Outdoor sports of various kinds were indulged in, with appropriate prizes to the winners. A feature of the event was the baseball game between the Robert Gair Club and the "Bunch," which resulted in a victory to the former by the score of 10 to 6. Dancing brought to a close a very enjoyable day.

Connecticut N. A. S. E. Convention—The annual state convention of the Connecticut N. A. S. E. will be held in Bridgeport, on June 26 and 27, in Eagles Hall, Madison Ave. The exhibition this year will be on a larger scale than that held two years ago, when Colonial Hall was taxed to its capacity.

The interest shown by the supply houses and the supply men's association in the coming convention and exhibition made it necessary for the committee in charge to engage the entire floor space of Eagles Hall. The expense is borne by the engineers and supply men, consequently the exhibition should be one of the finest and largest exhibitions of power plant and engine supplies ever produced in the state. The general committee of arrangement is as follows: F. J. Quinlan, chairman; Edward S. Birge, C. D. Osborn, W. Goodick, P. J. Grace, Jos. Bellwood. A. McNiel, Jr., F. Anderson, F. S. Buckley, N. S. Beushan, E. J. Grace, C. M. Dowd.

International Engineering Congress—The general subjects to be treated before this body at San Francisco, Sept. 20 to 25, 1915, will include these topics: Timber; Preservative Treatment of Timber; Substitutes for Timber in Engineering Construction; Brick in Engineering Structures; Clay Products in Engineering Structures; Probable and Presumptive Life of Concrete Structures Made from Modern Cements; Aggregates for Concrete; Slag Cement; Waterproof Concrete; Cements Containing Additions of Finely Ground Foreign Material; Economics of the World's Supply of Iron; The Life of Iron and Steel Structures; The Employment of Special Steel in Engineering Construction; The Place of Copper in the Present Engineering Field, and the Economics of the World's Supply Thereof; Alloys and Their Use in Engineering Construction; Aluminum in Engineering Construction; The Influence of the Testing of Materials upon Advances in the Designing of Engineering Structures and Machines; Cement Testing; Testing of Metals; Testing Full-Sized Members; Proof Testing of Structures.

The papers to be presented from the United States have already been arranged for from the recognized leading authorities on the various topics. Arrangements for the papers from foreign authors are being rapidly concluded, and the aggregation of papers which will be presented will constitute a broad review of the field and be of the highest value. Marked interest in the congress from foreign countries continues, and there is every evidence that the attendance from abroad will be large. It is hoped that all engineers in this country who have not yet subscribed as members of the congress will give the matter their immediate attention and favorable action. Full information concerning the congress may be obtained by addressing the International Engineering Congress, 1915, Foxcroft Building, San Francisco, Calif.

PERSONALS

F. N. Kollock, Jr., of the Westinghouse Electric & Manufacturing Co., has resigned his position as district manager of the Seattle office to accept the position of treasurer and assistant secretary of the Westinghouse Lamp Co., Bloomfield, N. J. W. D. McDonald, formerly branch manager of the Minneapolis office, has been appointed to succeed Mr. Kollock as district manager at Seattle, and C. C. Curry is acting branch manager at Minneapolis, succeeding Mr. McDonald.

OBITUARY

JOSEPH W. SWAN

Sir Joseph Wilson Swan, the inventor of the incandescent electric light and of the rapid dry plate, used in photography, died on May 27. He was 85 years old. Sir Joseph was born in Sunderland on Oct. 31, 1828. He served an apprenticeship with a chemist in Sunderland and became a member in a manufacturing chemists' firm in Newcastle. The firm made photographic plates and Swan's experience resulted in the first rapid dry plate and in the first commercially practicable process for carbon printing in photography.

He was one of the first to attempt the construction of an electric lamp using a filament of carbon. His first lamp of this kind was made in 1860, the filament being of carbonized paper. Thomas A. Edison adopted a similar method nearly twenty years later. Sir Joseph also conducted experiments and developed new methods in connection with the measurement of electric currents and improved accumulators.

He was elected a fellow of the Royal Society in 1894 and was knighted in 1904.